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AN ASSESSMENT OF THE U. S. TELECOMMUNICATIONS INDUSTRY DEPENDENCE ON FOREIGN SOURCES AS IT IMPACTS THE U.S. TELECOMMUNICATIONS INFRASTRUCTURE

APRIL 1994

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The production of telecommunications equipment used for National Security and Emergency Preparedness (NS/EP) purposes in the U.S. is dependent on sources for components and supplies from vendors outside the U.S. and Canada. The ability to mobilize the manufacturing of telecommunications equipment in response to natural disaster or war is of primary concern. A study of the foreign source dependence vulnerabilities in the process for manufacturing the Class-5 telephone central office switch was completed in 1993 by the Institute for Telecommunication Sciences (ITS) (Peach and Meister, 1993). Certain components were identified that could present a barrier to the timely mobilization of the Class-5 switch manufacturing. The vulnerabilities included several pieces of factory equipment and several consumable items that are necessary to produce the Class-5 equipment. The basis for discovery of foreign source dependence vulnerabilities is the possible need for rapid mobilization of U.S. telecommunications factories in the context of NS/EP. A rapid mobilization may mean the need for larger than normal quantities of raw materials, spare parts, or the need for additional equipment to provide additional communications capability for U.S. personnel.			
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NCS TECHNICAL INFORMATION BULLETIN 94-3

AN ASSESSMENT OF THE U. S. TELECOMMUNICATIONS
INDUSTRY DEPENDENCE ON FOREIGN SOURCES AS IT IMPACTS THE
U. S. TELECOMMUNICATIONS INFRASTRUCTURE

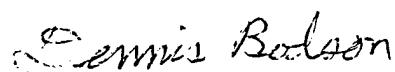
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FOREWORD

Among the responsibilities assigned to the Office of the Manager, National Communications System, is the management of the Federal Telecommunication Standards Program. Under this program, the NCS, with the assistance of the Federal Telecommunication Standards Committee identifies, develops, and coordinates proposed Federal Standards which either contribute to the interoperability of functionally similar Federal telecommunication systems or to the achievement of a compatible and efficient interface between computer and telecommunication systems. These systems constitute an important part of the overall infrastructure upon which the functioning of Government and economy relies. This report addresses the impact of foreign products and services on the U.S. telecommunications industry and assesses U.S. telecommunications and industry dependence on foreign telecommunications and information industry resources relative to mobilization needs of the U.S. telecommunications infrastructure. It has been prepared to inform interested Federal activities of the progress of these efforts. Any comments, inputs or statements of requirements which could assist in the advancement of this work are welcome and should be addressed to:

Office of the Manager
National Communications System
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TECHNOLOGY AND STANDARDS ANALYSIS REPORT

AN ASSESSMENT OF THE U.S. TELECOMMUNICATIONS INDUSTRY DEPENDENCE ON FOREIGN SOURCES AS IT IMPACTS THE U.S. TELECOMMUNICATIONS INFRASTRUCTURE

8 APRIL 1994

FINAL REPORT

REIMBURSABLE ORDER DNRO 26081

Prepared for:
The Office of the Manager
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PREFACE

This study was conducted for the National Communications System (NCS), Office of the Manager, Technology and Standards Office, 701 South Court House Road, Arlington, VA, under Reimbursable Order DNRO 26081. This report provides information that further defines vulnerabilities to the National Security and Emergency Preparedness (NS/EP) telecommunications operations and its capability to respond to mobilization of telecommunications manufacturing facilities required due to natural disaster or other emergency. NCS TIB 93-5 contains the results of an earlier study performed by NTIA in 1992. These studies were performed as a follow up to an initial assessment, in 1987, of the telecommunications industry's dependence on foreign sources in light of the potential requirement for mobilization.

The objectives of this study were, in part, to update the 1987 assessment and to develop a current evaluation of the NS/EP's dependence on foreign suppliers of components, subassemblies, raw materials, and other consumable materials used in the telecommunications equipment manufacturing process. This report contains data compiled from reference sources, interviews with industry representatives, and Government representatives. Certain commercial products and company names are mentioned in this report to specify and describe some of the information. Such identification does not imply exclusive recommendation or endorsement of the companies or the products by NTIA or the NCS. The views, opinions, and/or findings contained in this report are those of the author and should not be construed as an official NTIA or NCS position unless designated by other official documentation.

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ACRONYMS

AFCEA	Armed Forces Communications and Electronics Association
ASIC	Application Specific Integrated Circuit
CAGR	Compound Average Growth Rate
CPLD	Complex Programmable Logic Device
DoC	Department of Commerce
DoD	Department of Defense
DPAS	Defense Priorities Allocations System
DRAM	Dynamic Random Access Memory
DSP	Digital Signal Processor
EIA	Telecommunications Industry Association
EPA	Environmental Protection Agency
EPROM	Erasable Programmable Read Only Memory
FCCSET	Federal Coordinating Council for Science, Engineering, and Technology
FPLA	Field Programmable Logic Array
HFIA	High-Frequency Radio Industry Association
ITA	International Trade Administration
ITS	Institute for Telecommunication Sciences
LAN	Local access network
LED	Light-emitting diode
MOS	Metal Oxide Silicone
NCS	National Communications System
NS/EP	National Security/Emergency Preparedness
NSTAC	National Security Telecommunications Advisory Committee
PCS	Personal communications system
PLD	Programmable Logic Device
RBOC	Regional Bell Operating Company
SEM	Semiconductor Manufacturing and Testing Equipment and Materials
SIA	Semiconductor Industry Association
SIC	Standard Industrial Classification
SMR	Specialized Mobile Radio
SRAM	Static Random Access Memory
ST ² L	Schottky Transistor-Transistor Logic
T ² L	Transistor-Transistor Logic
TIM	Telecommunications Industry Mobilization
USITC	United States International Trade Commission

1. INTRODUCTION

The production of telecommunications equipment used for National Security and Emergency Preparedness (NS/EP) purposes in the United States is dependent on sources for components and supplies from vendors outside the United States and Canada. The ability to mobilize the manufacturing of telecommunications equipment in response to natural disaster or war is of primary concern. A study of the foreign source dependence vulnerabilities in the process for manufacturing the Class-5 telephone central office switch was completed in 1993 by the Institute for Telecommunication Sciences (ITS) (Peach and Meister, 1993). Certain components were identified that could present a barrier to the timely mobilization of the Class-5 switch manufacturing. The vulnerabilities included several pieces of factory equipment and several consumable items that are necessary to produce the Class-5 equipment.

The current effort was initiated by National Communications System (NCS) to assess the vulnerabilities within areas of the telecommunications infrastructure (other than Class-5 switch equipment) that are either key to the NS/EP systems or components in use or planned for procurement by the Government in the 1990s. Specific areas of potential problems (vulnerabilities) include the raw materials and the capability to manufacture certain components or systems. Raw materials, consumables, components, and subassemblies that receive value-added procedures during the manufacturing process are all included in this study. In addition, the factory equipment required during assembly, or other value-added manufacturing procedures is considered to be a critical element in the production of the final product.

2. SCOPE OF THE INVESTIGATION

An analysis of the dependence on foreign sources for the entire telecommunications infrastructure is desirable. Due to limitations of funding, the effort was reduced to a study of those lines of telecommunications products (and in some cases components), that are the basis for technology presently used by U.S. consumers.

The basis for discovery of foreign source dependence vulnerabilities is the possible need for rapid mobilization of U.S. telecommunications factories in the context of NS/EP. A rapid mobilization may mean the need for larger than normal quantities of raw materials, spare parts, or the need for additional equipment to provide additional communications capability for U.S. personnel.

The Gulf War of 1990-91 is a prime example of when a need for such mobilization existed. Communications were key to the success or failure of each undertaking during this war. Deployment of communications during the early stages of this war was simultaneous with the deployment of troops. High-tech equipment was requisitioned to outfit the troops as they were scattered throughout the region, increasing the need for a significant amount of additional radios and other telecommunications equipment.

Incidents of a similar type can occur without enough warning to adequately prepare for the need. The Department of Commerce (DoC) Defense Priorities and Allocations System (DPAS) Office¹ supported the Department of Defense (DoD) during the Gulf War. The DPAS Office handled 135 cases (91 cases pertained to U.S. forces, and 44 cases pertained to allied nation requirements) that required timely availability of industrial resources to meet defense requirements². Six high priority cases handled by DPAS during Operation Desert Shield/Storm involved foreign suppliers; five Japanese companies and two British companies were lower-tier vendors to U.S. companies. Each of the companies involved responded positively and were fully cooperative in providing accelerated deliveries of their respective products. Each of these cases was a potential problem; however, the prompt attention of the DPAS Office and the positive response of all involved avoided a crisis. Procurement of spare parts for repair of existing telecommunications equipment or purchase of new telecommunications equipment was involved in all cases.

The need for mobilization can also be driven by a disaster, such as Hurricane Hugo in 1990, Hurricane Andrew in 1992, Hurricane Iniki in 1992, the 1991 San Francisco Bay Area earthquake, the East coast blizzard of 1993, or the 1994 Los Angeles earthquakes. Unexpected failure of large pieces of telecommunications equipment (e.g., the 1988 Hinsdale fire) could require quick replacement of components or the complete system. The NS/EP needs that could not be met immediately during these disasters, ranged from a replacement Class-5 switch (not available off-the-shelf), to a need for telephone poles. In the case of Hurricane Hugo, the immediate supply of telephone poles was depleted early in the hurricane as it passed over the first of three Regional Bell Operating Company (RBOC) territories. The RBOC (Bell South) placed orders for replacement telephones. After passing over portions of the Bell South territory, the hurricane then passed over portions of Bell Atlantic territory, and finally over portions of NYNEX territory. An insufficient supply of telephone poles remained to replenish the damaged poles in the Bell Atlantic and NYNEX territories.

A mobilization of this industry (production of telephone poles) was required. In some cases the Government is requested to provide assistance in obtaining supplies in

¹The DPAS Office is responsible for establishing a system for obtaining timely delivery of critical industrial products and materials to support current defense requirements and maintaining a preparedness capability for industry to respond to any emergency. The DPAS Office is maintained by DoC, within the Office of Industrial Resource Administration (OIRA).

²This information was provided by Mr. Rick Meyers of the DoC's DPAS Office on July 8, 1993.

response to mobilization needs after a disaster. The DPAS Office was asked to provide assistance in procuring telecommunications equipment needed during the aftermath of Hurricane Andrew³.

The scope of this study will be limited to the high-tech components and systems that are likely to develop into instances of short supply during a mobilization. We have assumed that lower-technology items can be manufactured by U.S. companies within a reasonable time period, since the technology is readily available in the United States. The need to acquire foreign technology during a time of mobilization is a concern. For these reasons the following areas were singled out for this study:

- ◆ Semiconductor devices
- ◆ Telecommunications factory equipment
- ◆ Semiconductor factory materials
- ◆ Wireless products
- ◆ Fiber optic products.

3. LIMITATIONS OF THE INVESTIGATION

The completeness, and to some extent the success, of this study is somewhat limited due to time constraints and the extreme difficulty of obtaining accurate, precise, and current information. In some cases obtaining the correct data is very time-consuming, and in some cases the information is considered "guarded information" by the companies engaged in manufacturing a specific telecommunications system or component.

The use of a survey was determined to not be an effective approach for this study due to the reluctance of the companies to release data. It was also determined that The Defense Production Act of 1950 (requiring release of data critical to the defense, i.e., for NS/EP purposes) would not be appropriate to collect data for this study. However, it should be noted that The Defense Production Act of 1950 was used to aid the data collection for earlier studies (i.e., National Security Telecommunications Advisory Committee (NSTAC) sponsored studies in 1987-89) in determining foreign source dependence.

The extent to which the United States dependence on foreign sourcing produces vulnerability is complicated by the lack of a defined threat that could sever the supply source(s). The lack of a defined threat leads to difficulty in determining whether a dependence on foreign suppliers is a threat to national security. An example of this dilemma is illustrated by the Section 232 investigation conducted to determine the effect of imports of "ceramic packages" on national security. Although the United States is over

³Mr. Rick Meyers, DoC DPAS Office, July 8, 1993.

90 percent sourced from Japanese companies, it was determined that no threat to national security exists because those Japanese companies manufacture a significant amount of the ceramic packages at factories in the United States. This conclusion was reached because there is a domestic source (though foreign-owned), and that source has been reliable in the past. It was noted, however, during this study that this foreign firm depends on its parent overseas organization for all green tape (i.e., unfired ceramic, and several other critical inputs to the process) for packages produced in the United States (DoC, 1993).

These results are provided in a recent report, published by the Department of Commerce, Bureau of Export Administration (BXA)(DoC, 1993), entitled "The Effect of Imports of Ceramic Semiconductor Packages on the National Security." This report notes that: "As a result of the changing national security challenges facing this country, the Department of Defense is currently unable to identify its exact quantitative requirements for ceramic semiconductor packages during a national security emergency." This is not only true for ceramic packages, but any of the other components, or materials that are sourced predominantly from outside the United States. The threat to the mobilization of the NS/EP communications network comes from the lack of our ability to quickly produce additional telecommunications equipment or to make available spare parts needed to repair existing equipment. The threat of disruption of supply of foreign sourced components, such as ceramic packages for semiconductors, comes primarily as a result of economic conflict, rather than a hostile action.

As reported in various newspapers, the Nation may now have a more significant threat from disaster, rather than war. With the breakup of the Soviet Union and the dismantling of the Berlin Wall, the threat from adversaries is thought to be decreased. Other analysts believe the major threat could be from the "economic war" that is underway or is imminent. It has become apparent that the threat is not obvious. For the purposes of this report, the threat will be defined as a "disruption of supply."

Most of the products that are threatened by a disrupted supply of components or materials are in the high-technology arena. The technology turnover in these areas is rapid, resulting in short-term vulnerabilities in some cases. A good example of this has been the hierarchy of the Dynamic Random Access Memory (DRAM). The progression of memory sizes has transitioned from 64K (kilobit) to the now commonly used 1M (megabit) or 4M DRAMs. The turnover rate of such technology has decreased to two years or less. An identified foreign sourcing vulnerability with one size DRAM disappears as the next larger size DRAM is used in the design of the next generation of product. The new technology may of course create a new foreign sourcing vulnerability. Because of the inability to isolate one type of DRAM, or Static Random Access Memory (SRAM), or other specific integrated circuit, it was decided to treat the whole group of semiconductors as a "problem" area.

4. SEMICONDUCTOR DEVICES

The dependence on foreign sources for certain semiconductor devices and components was evident in earlier studies (NCS, 1987), and as a result of the Institute for Telecommunication Sciences (ITS) studies completed in 1992. During the 1992 studies, it was determined that U.S. companies were competitive in supplying all semiconductor devices except DRAM and SRAM devices. In particular, the markets for DRAMs and SRAMs of 4 Mbit and larger are primarily dominated by sources outside of North America.

Technology and asset turnover in the semiconductor manufacturing business is rapid. Often the benefits resulting from successful accomplishments cannot be realized by the firms that make the investment; the high risks entailed in long-term technology and equipment development are a strong disincentive. Sematech⁴, a partnership that includes eleven semiconductor companies and the Government, has made a difference. Due to limited resources and lack of uniform equipment specifications throughout the industry⁵, previous partnerships between semiconductor producers, and equipment and materials suppliers, had proven insufficient to produce industry leadership. Sematech has been able to assist the member companies to work together with a single qualification methodology for key processing equipment.

The worldwide sales of semiconductors have grown over 300 per cent during the decade from 1980 to 1990. Three U.S. companies were among the top five producers, and five U.S. companies were among the top ten semiconductor producers in 1980. In 1990, only two U.S. companies were among the top five, and three U.S. companies were among the top ten semiconductor suppliers. These facts are illustrated in Figure 1⁶, along with a measure of the total market size.

The losses from 1980 to 1990, as shown in Figure 1, resulted in U.S. companies losing their lead in the semiconductor equipment market. Since 1990, U.S. companies have regained their lead as shown in Figure 2⁷. Some of the credit for the recovery should be given to Semi/Sematech, a company dedicated to improving the competitive position of

⁴Sematech is located in Austin, TX.

⁵This information is from internal reports used by Sematech, Austin, TX, in their effort to assist their industry members to become more competitive in the semiconductor industry.

⁶Dataquest is a telecommunications market research company based in San Jose, CA.

⁷SIA--Semiconductor Industry Association, San Jose, CA.

U.S. companies that are suppliers of semiconductor factory equipment and materials. Normal business cycles, due to economic changes, are probably responsible for the remainder of the recovery. Possibly the recovery would not have happened as quickly as it did without the efforts of Semi/Sematech.

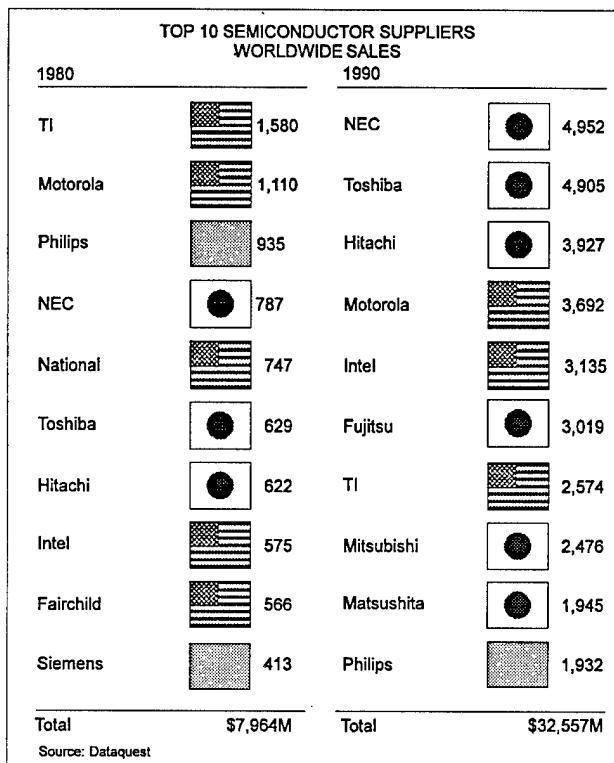


Figure 1. Top ten semiconductor suppliers.

A recent update from Dataquest⁸, Inc., details the world semiconductor market share by the North American, Japanese, European, and Pacific Rim manufacturing segments. Recently compiled 1992 data shows the two largest semiconductor markets (in dollar value) are: (1) the DRAM memory (57% of the world market) and (2) the SRAM memory (20% of the world market). The worldwide and North American market share is distributed as shown in Table 1.

Semiconductor component segments that are expected to experience a significant increase in share of the world semiconductor market in the next few years include metal oxide silicon (MOS) components. The MOS technology is used to manufacture DRAM, SRAM, and other memory component products. Segments of the semiconductor market

⁸Dataquest, Inc. is market analysis company that offers a market update service to service subscribers.

that will sustain the greatest growth in the next few years are listed in Figure 2.

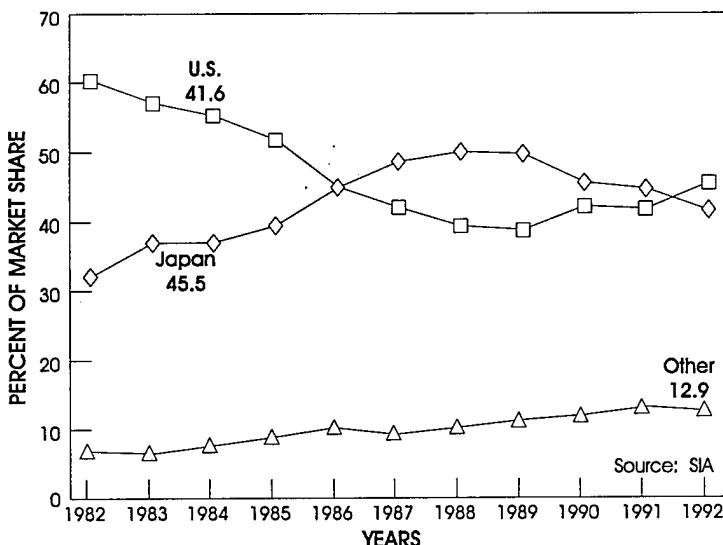


Figure 2. The U.S. passes Japan in worldwide integrated circuit market share.

In MOS memory technology two semiconductor component types showed the fastest growth in 1992—DRAMs and flash memories. These products also attracted the greatest activity in formation of production alliances between large U.S., Japanese, and European companies. In the past these alliances have resulted in significant U.S. technology outflow.

Table 1. Market Share Distribution

A. Worldwide Market Share Distribution

	DRAM	SRAM
North American Companies	18.0%	23.3%
Japanese Companies	54.1%	61.7%
European Companies	3.6%	1.8%
Asia/Pacific-ROW Companies	24.3%	13.2%

B. North American Market Share Distribution

North American Companies	22.9%	44.0%
Japanese Companies	49.4%	47.4%
European Companies	1.7%	0.8%
Asia/Pacific-ROW Companies	25.39%	7.8%

ROW - Rest of World

Some industry experts have conceded the DRAM market to foreign producers, however; three U.S. companies are among the top 15 producers in the world. The supply of DRAMs continues to outpace the demand, and the price continues to fall faster than U.S. companies can reduce costs. The result is a less than favorable competitive position for U.S. companies.

Table 2. World Semiconductor Market, 1992-95
(in billions of dollars)

Product	Percent			
	1992 ¹	1995 ²	1992	1995
MOS Memory	13.8	20.2	24.1	26.1
MOS Microcomponents	12.6	18.4	22.0	23.8
MOS Logic	9.5	13.4	16.6	17.4
Bipolar	3.0	2.6	5.3	3.4
Analog	8.3	10.7	14.5	13.8
Discrete devices and optoelectronics	10.0	12.0	17.5	15.5
TOTAL	57.2	77.3	100.0	100.0

¹Estimate

²Forecast

A reverse position exists for flash memories that also use MOS technology. Although the flash memory technology is a Japanese invention, U.S. companies command more than 90 percent of the market⁹. If the demand for flash memories continues to develop, and if U.S. companies cannot keep pace with the competition's cost reductions, a situation similar to the DRAM scenario could develop.

In the MOS microcomponent category, the fastest growing product types are microcontrollers and microprocessors. Industry experts¹⁰ expect that the microcomponent market will exceed the MOS memory market in size by the year 2000. Microcontrollers are used in a variety of applications, including consumer electronics, auto parts, robotics, and

⁹Source: The Department of Commerce, International Trade Administration, *U.S. Industrial Outlook 1993*.

¹⁰Projections are from Dataquest, Inc., San Jose, CA.

telecommunications. The DoC estimates¹¹ that the Japanese have more than 60 percent of the world microcontroller market; the U.S. is second with close to 30 percent. Sales of microcontrollers to the automobile industry rose significantly in 1992 because they are an essential component of anti-lock brake systems and dashboard instrumentation.

The DoC also estimates¹² that U.S. companies have more than 80 percent of the world microprocessor market. Three of the top five, and six of the top ten companies that produce microprocessors are U.S. companies. Microprocessors are the key semiconductor component for processing information in PCs and computer workstations.

4.1 Background Information

Future trends in the size of semiconductor component consumption, in the United States and worldwide, are difficult to estimate. A recent analysis¹³, summarized in Table 3 and Table 4, illustrates how the consumption of semiconductors tracks with the

Table 3. Total Worldwide Semiconductor Market Consumption
(in percent of total market)

Supplier Region/Country	1988	1989	1990
North American	70.3	65.3	68.7
Japanese Companies	20.7	25.5	21.7
European Companies	6.3	5.7	6.2
Asian/Pacific Companies	2.6	3.5	3.4

relative economies of the world. The tables show that as the U.S. economy improves (approximately 1990), the consumption of semiconductors increases. As Japan's economy declined (1989-90), their consumption also declined.

¹¹Source: U.S. Department of Commerce, International Trade Administration, *U.S. Industrial Outlook 1993*.

¹²Source: U.S. Department of Commerce, International Trade Administration, *U.S. Industrial Outlook 1993*.

¹³By Dataquest, San Jose, CA.

Table 4. MOS Memory Market Consumption

Supplier Region/Country	1988	1989	1990
North American Companies	40.1	34.9	34.0
Japanese Companies	49.1	53.1	50.9
European Companies	3.1	2.9	3.9
Asian/Pacific Companies	7.7	9.2	11.2

4.2 Summary

The trends¹⁴ of the semiconductor market for 1993 include a transition from T²L logic and 1 Mb memory devices to 4 Mb memory devices and the use of more microprocessors and programmable logic arrays. Table 5 summarizes these trends.

Table 5. Trends in Use of Semiconductor Devices in 1993

HOT		PERCENT GROWTH
4 Mb DRAMs		38.0
32 bit Microprocessors		19.0
Flash Memories		103.0
CPLDs and FPLGAs		31.0
NOT SO HOT		PERCENT GROWTH
1 Mb DRAMs		- 28.0
ST ² L Logic		- 14.0
1 Mb EPROMs		- 17.0
Bipolar PLDs		- 18.0
KEY: CPLD - Complex Programmable Logic Device		
FPLA - Field Programmable Logic Array		
EPROM - Erasable Programmable Read Only Memory		
DRAM - Dynamic Random Access Memory		
PLD - Programmable Logic Device		
ST ² L - Schottky Transistor-Transistor Logic		

¹⁴Data from Dataquest, San Jose, CA semiconductor industry update.

4.3 Mobilization Response Timeframes

The NS/EP planners have tried to project their success in terms of the time it takes to recover from a disruption in supply of components or materials. These timeframes are discussed in a report published by the NCS (Peach and Meister, 1993). Being able to respond in a timely manner if and when a disruption of supply occurs, is of utmost importance to the NS/EP planning activities. The appropriate response depends on the product, component, or material involved. In some cases the response can be as simple as redirecting existing inventories of commodities; however, if supply of an item does not exist, a capacity to produce that item may have to be built. For many items this can be a very serious problem. In the case of semiconductors, the lead time for constructing and bringing a semiconductor process facility to full production can be one to two years. Figure 3 summarizes the start-up time required to plan, construct, and debug the process for three production scenarios: a low-technology, high-volume process line; a state-of-the-art, low-volume (pilot line) process line; and a state-of-the-art, medium-volume process line. Constructing a process line for semiconductors, especially a high-technology (very narrow line width) process for a state-of-the-art semiconductor device requires acquisition of specialized components, non-standard materials, personnel with specialized skills, and the coordinating of these materials and personnel. In some cases the availability of a particular commodity or skill may be dependent on whether another semiconductor plant is being built elsewhere in the world.

LOW TECH / HIGH VOLUME (2 - 5 μ) \$500M INVESTMENT			
PLANNING CYCLE	CONSTRUCTION CYCLE	PROCESS DEBUG	YIELD
10 - 12 WEEKS	14 WEEKS	10 WEEKS	20% - 30%
TOTAL = 34 - 36 WEEKS			
 STATE-OF-THE-ART (high tech) PILOT LINE (low volume)			
PLANNING CYCLE	CONSTRUCTION CYCLE	PROCESS DEBUG	YIELD
12 WEEKS	20 WEEKS	16 WEEKS	20% - 30%
TOTAL = 48 WEEKS			
 STATE-OF-THE-ART (high tech) MEDIUM VOLUME (0.3 - 2 μ) \$1 - 2B INVESTMENT			
PLANNING CYCLE	CONSTRUCTION CYCLE	PROCESS DEBUG	YIELD
12 WEEKS	38 WEEKS	16 - 20 WEEKS	20% - 30%
TOTAL = 65 - 70 WEEKS			

Figure 3. Typical start-up times for semiconductor processes.

4.4 Foreign Source Dependence

The vulnerability due to foreign source dependence for semiconductor devices is severe, based upon the time that it takes to build additional capacity. The time that it takes to build a process line for state-of-the-art devices that are not already being manufactured in the United States will be even longer due to the learning curve required to gain experience in making such devices. As a first step, it is imperative to develop a capability to manufacture all types of semiconductor devices in the U.S. to avoid the situation in which United States manufacturers do not have the experience to develop and operate a high-technology semiconductor process.

5. FACTORY EQUIPMENT

Until 1990, the U.S. manufacturers' percent of semiconductor factory process equipment was declining. Recently compiled data from Semi/Sematech, an Austin, Texas-based industry consortium shows that U.S. companies have captured over one-half of the world market for semiconductor factory equipment. The current share of the market is above that attained in 1989, as shown in Table 6¹⁵.

Table 6. U.S. Manufacturer's Share of the World Semiconductor Factory Equipment Market

YEAR	PERCENT OF MARKET
1989	47.8
1990	43.9
1991	46.6
1992	50.5

Source: Semi/Sematech, Austin, TX

The previous progressive loss of the U.S. market share for factory equipment is shown in Figure 4. The substantial lead that the U.S. manufacturers enjoyed in the early 1980s was

¹⁵Semi/Sematech represents an industry consortium and assists its members in assessing the U.S. supplier community's competitive position in various National and International markets.

lost, but seems to be on the recovery track at the present. This turnaround began about 1990, as illustrated in Figure 4, shortly after the formation of Sematech and Semi/Sematech.

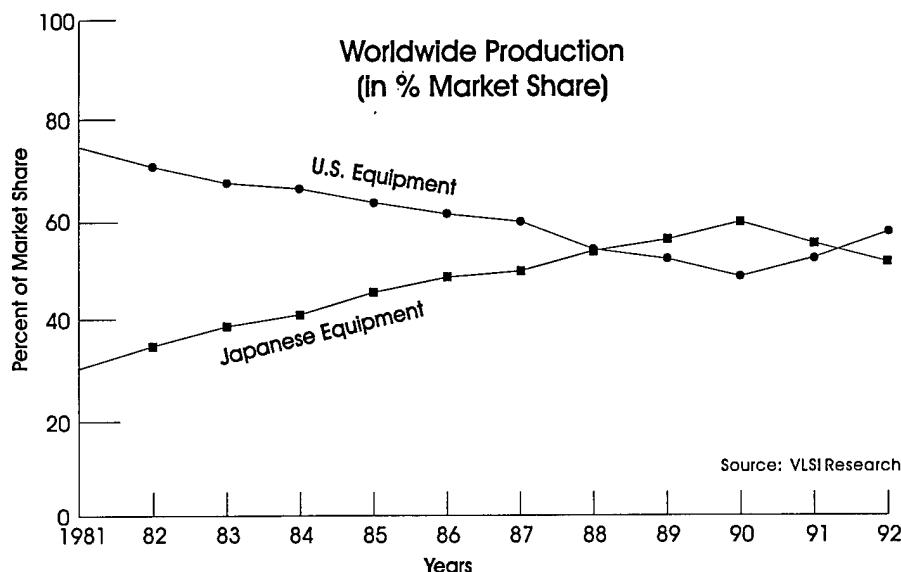


Figure 4. The global semiconductor process equipment market.

As early as 1979, the semiconductor industry recognized that rapidly escalating research and development costs, resource limitations, and the nature of global competition in the semiconductor field required an industry-wide approach to coordinate and support long-range technology development. It was clear that independent and redundant efforts by U.S. semiconductor companies, the DoD, and processing equipment and materials suppliers would be insufficient to provide technology leadership. These conclusions were echoed in a Defense Science Board study on dependence of supply for critical semiconductor components for defense. Leadership of U.S. companies in the global equipment market was very good in 1980, as illustrated in Figure 5¹⁶; however, the picture was changing and would significantly change by 1990 as depicted in Figure 5.

A semiconductor factory process requires significant equipment assets to perform many of the process operations. Figure 5 illustrates the U.S. companies' competitive position in the world market. In addition to the equipment required to manufacture semiconductors, many other raw materials and consumable items are required in the process. For example, one Japanese company provides over 50 percent¹⁷ of the world

¹⁶VLSI is market research firm located in the San Jose, CA area.

¹⁷The *Wall Street Journal*, July 21, 1993, Memory-Chips Supply is Hit by Japan Blast.

requirements for epoxy resin, with Japanese suppliers providing over 90 percent of the world requirement. A July 1993 explosion within the plant of the major supplier curtailed production, and as a result has slowed several semiconductor manufacturing plants that rely on this source of resin. A shortage (real or imaginary) of DRAMs has resulted, and the price has escalated to as much as 50 per cent of the price just prior to the explosion.

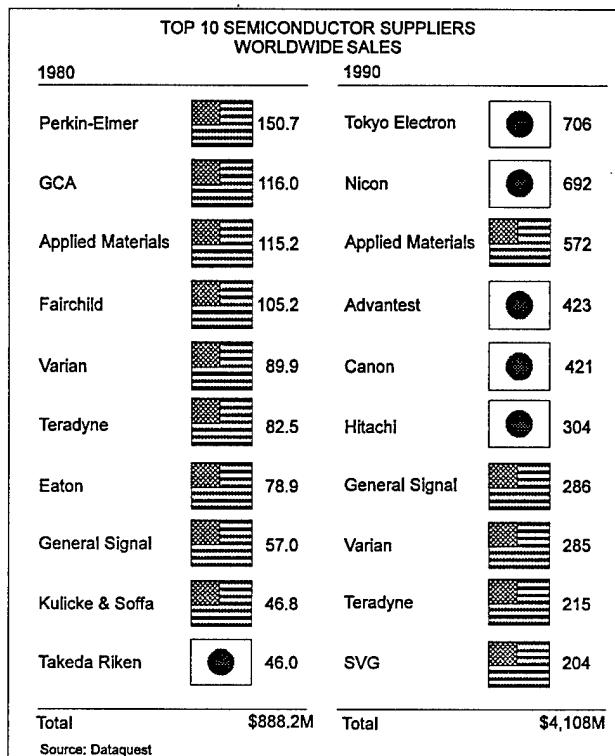


Figure 5. The top ten semiconductor equipment suppliers.

A true indicator of the reliance on foreign sources for semiconductor equipment would be an actual analysis of a recently capitalized fabrication plant. Two examples are available: the Motorola MOS 11 plant completed in 1992 in Austin, TX and the "Pentium" chip fabrication plant being built by Intel, in Rio Rancho, NM in 1993. Early in the planning cycle for the MOS 11 plant, a Senior Vice President at Motorola indicated the benefit of Sematech in their planning process. This Vice President is quoted as saying:

"Sematech has had a significant impact on MOS 11. When we first started planning for the facility a few years ago, we anticipated that the majority of the equipment would have to be sourced outside the U.S. Things have changed over the last couple of years, largely through the help of Sematech and through a lot of work on

the part of individual equipment manufacturers. When MOS 11 actually opens, it will contain about 80 percent U.S.-manufactured equipment¹⁸."

After the plant was completed, actual procurement summaries indicate that 85 percent (dollar amount) of the process equipment was purchased from U.S. sources¹⁹. This is an indication that U.S. equipment is adequate for deploying a state-of-the-art semiconductor production facility. During discussions with representatives of Semi/Sematech and Sematech, it became evident that the industry is fraught with opinions that U.S.-made semiconductor factory equipment is of lower quality than foreign-made equipment. These opinions are thought to be a result of negative experiences with U.S.-made equipment in the early 1980s, along with very effective promotion from foreign-product manufacturers.

5.1 Industry Views on Competitiveness

Continued growth of the U.S. companies supplying factory equipment, materials for manufacturing, semiconductor devices, or telecommunications products depends largely upon the competitive edge that U.S. companies can maintain. U.S. companies have been able to compete and have increased their share of the market for semiconductor factory process equipment, in spite of the significant disadvantages of operating in the United States compared to operating in Japan. Two areas of concern are frequently mentioned by U.S. companies: the R&D tax write-off schedule, and the depreciation schedule. A comparison of U.S. and Japanese depreciation schedules for a typical piece of semiconductor manufacturing equipment (wire-bonding equipment) is shown in Figure 6²⁰. The U.S. companies must depreciate their assets over four to seven years, usually straight line, while Japanese companies are allowed to depreciate their equipment over three or four years, and if the equipment is used more than eight hours/day, Japan allows an even more rapid depreciation²¹.

¹⁸Mr. Tommy George, Vice President, Motorola, Inc., Sematech "Strategic Overview" Technical Brief, December 1991.

¹⁹Ms. Vicky Farr and Mr. Darroll Paiga of Semi/Sematech, Austin, TX.

²⁰Source: American Electronics Association, as cited in United States International Trade Commission (USITC) Publication 2434, September 1991.

²¹Information obtained from a Report to the Committee on Finance, United States Senate, on Investigation No. 332-303 Under Section 332(g) of the Tariff Act of 1930, entitled *Global Competitiveness of U.S. Advanced-Technology Manufacturing Industries: Semiconductor Manufacturing and Testing Equipment*, United States International Trade Commission (USITC), Washington, DC 20436, September 1991.

However, some analysts maintain that product performance and technology, financial viability, and the health of the market are the primary factors that determine whether a U.S. company can be competitive in a particular market. A good example is the Semiconductor Manufacturing and Testing Equipment and Materials (SEM) companies. The factors that led to competitiveness of SEM companies in the semiconductor market²² are:

- ◆ the development of stable sources of financing for R&D
- ◆ the success of cooperative relationships with domestic or foreign customers
- ◆ the growth of the domestic market for SEM products and the ability of U.S. firms to establish a presence in foreign markets.

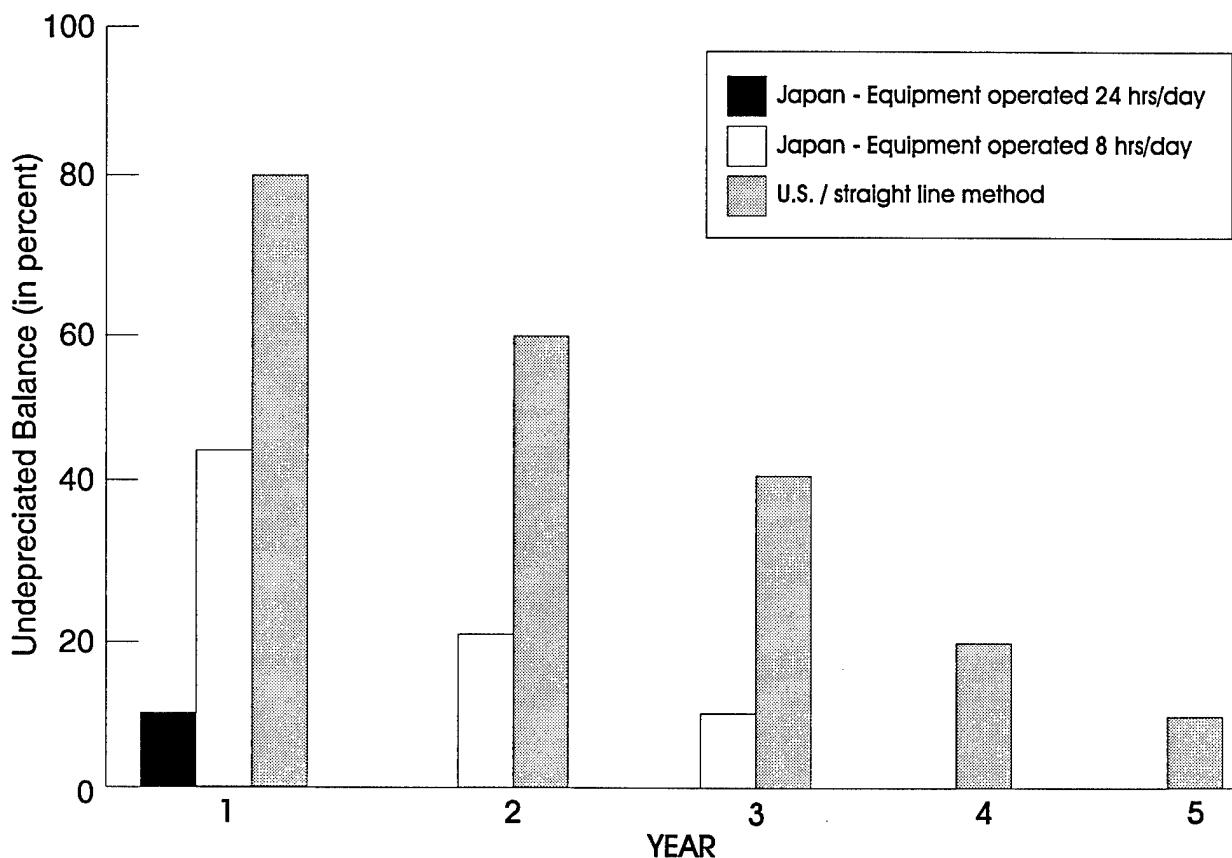


Figure 6. Wire bonding equipment: total income tax depreciation schedules, U.S. and Japan, 1990.

²²Ibid., p. 5-2.

The size of the company is another element in determining whether a company can succeed in a particular market²³. Smaller companies are less likely to attract sufficient capital to purchase the state-of-the-art equipment required to build a high-technology factory. Large firms and nationally owned (Government owned or substantially subsidized) firms tend to be immune to this problem, because they can raise the capital necessary to compete in the high-technology arena.

Based upon the fact that factories in different parts of the world operate under quite different rules and restrictions (based upon the individual country's laws), and some of these rules seem to favor the factories outside of the United States, one could surmise that the "playing field" on which we play the economic game is not "level." However, there are other factors that affect the competitive position of a U.S. company than those mentioned above. These factors include the operational costs associated with operating the factory, the time to prepare a new product for production, and the level of investment for the factory (Womack et al., 1990).

5.2 Another Perspective on Competition

An analysis by J.P. Womack and others (Womack et al., 1990) illustrates a few other differences that may have a significant effect on the competitive position of U.S. companies. Two types of production philosophy have emerged as a result of this study: (1) mass production, as developed by Henry Ford, and used successfully by manufacturers such as Ford Motor Co., General Motors, and Chrysler; and (2) lean production, originating in Japan and used successfully by companies such as, Toyota and Nissan for manufacturing automobiles in Japan and the United States.

Mass production originated with the Model T Ford, based upon Henry Ford's twentieth design of the Ford automobile in five years. Ford had finally achieved two objectives: a car that was designed for manufacture, and a car that could be driven and repaired without a chauffeur or mechanic. As related in a book entitled "The Machine that Changed the World," (Womac et al., 1990) the key to mass production wasn't—as many people then and now believe—the moving or continuous assembly line, *rather, it was the complete and consistent interchangeability of parts and the simplicity of attaching them to each other* (emphasis added). Automation of the factory was also important, and became a standard that factories of the world sought to duplicate. The heyday of mass production was in the 1950s.

Lean production, as defined by Womack (Womack et al., 1990), began to evolve as a result of a conclusion (in the early 1950s) by Toyota Motor Company's engineer, Eiji Toyoda, and his production manager, Taiichi Ohno, that mass production could never

²³Information from Semi/Sematech, Austin, TX.

work in Japan. The formulation and perfection of lean production continues even today. Lean production requires:

- ◆ $\frac{1}{2}$ the human effort in the factory
- ◆ $\frac{1}{2}$ the manufacturing space
- ◆ $\frac{1}{2}$ the investment
- ◆ $\frac{1}{2}$ the engineering hours
- ◆ $\frac{1}{2}$ the time to develop new products.

The analysis performed by Womack (Womack et al., 1990) shows that lean production techniques have achieved almost a 2:1 advantage in "Assembly Hours" and "Assembly Space" required per car, and an advantage of approximately 3:1 in "Defects" per car. Womack states that in terms of manufacturing space, the lean production factory was 40 percent more efficient, and its parts inventories available at the work station were a tiny fraction (2 hours vs 2 weeks) of those for a typical mass production factory.

The quality-enhancing ideas of W. Edwards Deming appear to be the seed for the development of "lean production" techniques. The ideas of Deming are summarized by the Associated Press²⁴, and are presented in the fourteen points below.

1. Create constancy of purpose.
2. Adopt the new philosophy.
3. Cease dependence on inspection to achieve quality.
4. Cease doing business on the basis of price tag alone.
5. Improve constantly and forever the system of production and service.
6. Institute training on the job.
7. Institute leadership.
8. Drive out fear so that everyone may work efficiently.
9. Break down barriers between departments.
10. Eliminate slogans, exhortations, and targets.
11. Eliminate numerical quotas.
12. Allow pride in workmanship.
13. Institute a program of self-improvement.
14. Put everybody in the company to work to accomplish the transformation.

The implementation of these ideas is probably the key to the success of the Deming philosophy and the success of "lean production." Is "lean production" the key to success in the 1990s? Or is "lean production" just the next generation of factory philosophy or technique to be replaced by yet another generation? Only time will tell.

²⁴Associated Press, *Daily Camera*, Boulder, CO, December 21, 1993, "Deming, a Management Innovator, Dies at 93."

5.3 Foreign Source Dependence

In 1993, the dependence on foreign sources for semiconductor devices used in telecommunications products is limited to a few types of memory devices. U.S. companies can produce all of the types of semiconductors; however, the market for certain devices is dominated by the Japanese and others. Since U.S. companies can produce all of the required devices, although sometimes in smaller quantities, the questions become: can the volume of production be increased to produce more of those devices? If the semiconductor capability must be increased quickly, can the manufacturing process equipment be procured from U.S. sources?

6. FACTORY MATERIALS

Consumable materials are a necessary part of any factory process. Raw materials that receive "value-added" procedures or process modification are also critical to the process. A lack of any one of the many materials can preclude the manufacturing of that product. This study concludes that the United States has a significant vulnerability because of the foreign sourcing of certain materials.

The study performed in 1987 (NCS, 1987) did not identify any raw materials or consumable materials used in factories that were sourced from foreign suppliers. Several components were identified by the survey performed as part of the study. In the DoC/NTIA study performed in 1992 (NCS, 1993), it was determined that some of the components identified in the 1987 study were still being supplied by foreign companies. In addition, it was determined that several consumable materials used in telecommunications equipment factories were being supplied by foreign companies. This study confirms the results of the 1992 study, and also concludes that the sourcing of "starter" materials (a mix of consumable and raw materials and certain other value-added materials) for making components and devices (e.g., semiconductor devices, liquid crystal displays, flat panel displays, etc.) are a problem.

Semiconductor consumable and raw materials have been identified as areas of vulnerability. Semiconductors are necessary components for computers, which are an integral part of our culture and society. The Wall Street Journal has referred to the problem of foreign-sourced materials as a "hidden vulnerability" for the computer maker (Hamilton, 1993). The vulnerability illustrated by the Sumitomo Chemical explosion is that a disproportionate share of the world capacity of certain materials may be produced at a single site. An NS/EP scenario includes the concern that these sites are subject to natural disasters, equipment failures, human error, and sabotage.

The Wall Street Journal (Hamilton, 1993) refers to these single supplier materials as "chokepoints" in our manufacturing process. Whether these concentrations (a large portion

of the U.S. supply of a single material) are viewed as a vulnerability depends on the threat. The NS/EP planner must evaluate the likelihood that a particular supply will be cut off or interrupted. In the case of a natural disaster, this task is very difficult. The only real insurance is the development of diverse sources for all critical materials—if all the chokepoints can be identified.

The time allotted for this study did not allow for the determination of "all" of the vulnerabilities (materials that have disproportionate portion of their supply coming from foreign sources) that exist in even one manufacturing process. A few of the chokepoints in the semiconductor process are discussed by the Wall Street Journal (Hamilton, 1993). A summary of the instances of foreign source vulnerabilities in the manufacturing process for the microprocessor, the "engine" that runs our PCs, is presented below.

- ◆ **ceramic packages**—70% of the world market from a single supplier, Kyocera Corp., at a plant in Kokubar, Japan. Used to encase microprocessor chips in PCs.
- ◆ **magnetic ferrite**—45% of the global market share comes from TDK Corp., at a single plant in Kofu, Japan. Used to make the read/write magnetic "head" needed to source and sink data in a PC's disk drive.
- ◆ **dicing saws**—70% of the saws come from Disco Corp., which manufactures saws at two factories in Japan. Used to dissect a finished wafer into microprocessor chips that can be packaged for use in a PC.
- ◆ **"steppers"**—50% to 70% are made by Nikon Corp., at a single factory in Japan's Saitama Prefecture. Used to precisely locate the placement of each layer as it is applied in the microprocessor chip manufacturing process.
- ◆ **photomasks**—40% of the world market comes from Dai Nippon Printing Co. at two factories in Japan. Used as a "stencil-like" outline on the quartz (silicon) wafer during the making of a microprocessor chip.
- ◆ **ultraviolet light bulbs**—70% of the bulbs are made by Ushiro Inc., at a plant in Harima, Japan. Used during the process of applying the layers on a wafer during the manufacturing process for a microprocessor chip.
- ◆ **quartz plates**—Two thirds of the world's supply of blank quartz plates, used to make photomasks, are made by Hoya Corp., at two locations in Japan.

The Wall Street Journal article (Hamilton, 1993) relates that these examples are merely among the most obvious. A representative of Semi/Sematech²⁵, in an address to the ITS in Boulder, CO, cites several more examples that have been discovered by Semi/Sematech, Austin, TX (See Appendix A).

U.S. manufacturing facilities assume significant risk due to the reliance on foreign suppliers for materials required for producing telecommunications products. Interruption of supply is a very real possibility, as illustrated by several examples in this report. As a result, the NS/EP infrastructure is vulnerable, and the ability to mobilize is not assured.

The stability and viability of our manufacturing capability derives from the availability of materials to build quality products. As mentioned earlier in this report, U.S. companies are divesting themselves of low profit materials production operations, and companies in Japan are seizing upon the opportunity to invest in these operations. Enterprises in other parts of the world (i.e., Korea, China, Taiwan, the European Community (EC), and the former Soviet States) are following Japan's example. Mr. Clay Prince, a competitive analyst for Sematech, Austin, TX provided more information on this subject at a briefing presented at the Department of Commerce, Institute for Telecommunication Sciences, Boulder, CO on October 8, 1993. An Abstract of this presentation is included in Appendix B.

7. FIBER OPTIC PRODUCTS

The worldwide growth rate, as projected by KMI Corp., Newport, RI, at their annual conference for the fiber optics market remains strong; the compound average growth rate (CAGR) is 59 percent²⁶ for the 6-year period 1992 through 1998. The North American region is projected to grow 13 percent during that period, while the emerging markets are expected to grow at a rate of 24 percent. In the United States, the cable lengths are getting shorter as fiber moves from long-haul to feeder to distribution, and then to the drop²⁷. The growth rate projected for the United States (and Canada) ensures a continuing demand for products to support this technology. The NS/EP requirement will only increase, and as

²⁵Ms. Peggy Haggerty, Semi/Sematech, Austin, TX, The Institute for Telecommunication Sciences, Boulder, CO, October 8, 1993.

²⁶Kessler Marketing Intelligence (KMI Corporation), Newport, RI, The 16th Annual Newport Conference on Fiberoptics Markets, October, 1993.

²⁷The "drop" is the relatively short cable required to connect a residence from the "curb" to the wall outlet. The term "distribution" refers to the cable used to distribute service along a street, in a neighborhood, from the central office. A "feeder" is the somewhat longer cable that provides the fiber optic backbone to the central offices.

a result will increase our sensitivity to foreign source dependence of our fiber optics product factories.

The U.S. consumption of fiber cable and fiber components is changing as the transition from long-haul to short-haul takes place. Figure 7 illustrates the change in types of installation from 1992 to 1998. Installations will require almost exclusive use of single-mode fiber through the 1990s (92.7% single-mode in 1990 vs 92.2% single-mode in 1998)²⁸.

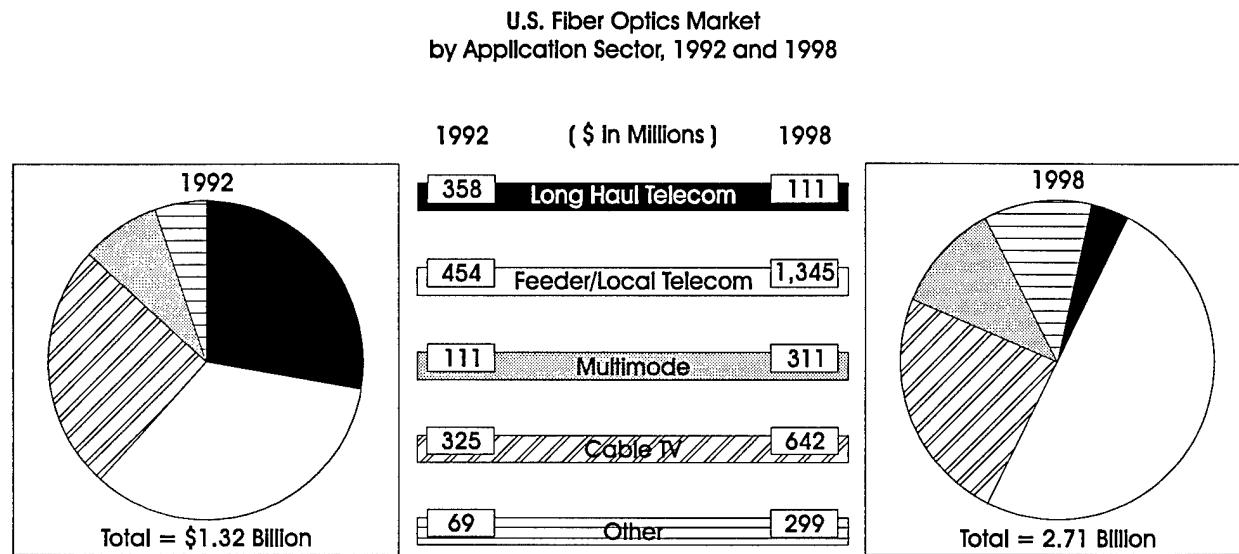


Figure 7. The changing use of fiber cable in the U.S.

As the demand for video-to-the-home increases with the proliferation of cable services, certain experts are attempting to analyze the capability of our nation's fiber cable capacity. Mr. Peter Scovell²⁹, Managing Director, Optoelectronics, at Northern Telecom, estimates that we must plan to provide a minimum capacity of 40 to 50 gigabits per second of data throughput by the end of the decade (see Figure 8). Currently, companies are preparing to deploy systems that will increase our capacity to 10 gigabits per second. Whatever the increase may be, experts in industry agree that the demand for more capacity will increase in the future, increasing the demand for high-tech fiber optic components. The key components of any fiber optic system are the optoelectronic components, and the transmit and receive devices required to send information (data, video, etc.).

²⁸Projections by KMI Corp., The 16th Annual Newport Conference on Fiberoptics Markets, October, 1993.

²⁹Mr. Peter Scovell, The 16th Annual Conference on Fiberoptics Markets, Newport, RI, October, 1993.

The result is that the fiber cable industry will be a high-growth area, and as a result, the components associated with the cable will also see growth. The only components in this system that are of concern are the optoelectronic devices. At present, it is of little concern; however, as the demand for these devices increases, additional capacity for production will develop, most likely offshore. For the NS/EP planner, this could be a problem.

In 1993, the BXA at the DoC conducted an assessment of six technologies deemed critical to the national security of the nation. Optoelectronics, which includes equipment used in fiber optic transmission systems, was among these technologies. A survey was used to determine the U.S. companies' strength in the marketplace. The companies were asked to rate themselves, using as a baseline their Japanese and European competitors. The results are summarized in a Department of Commerce, an ITA report, published in 1994³⁰.

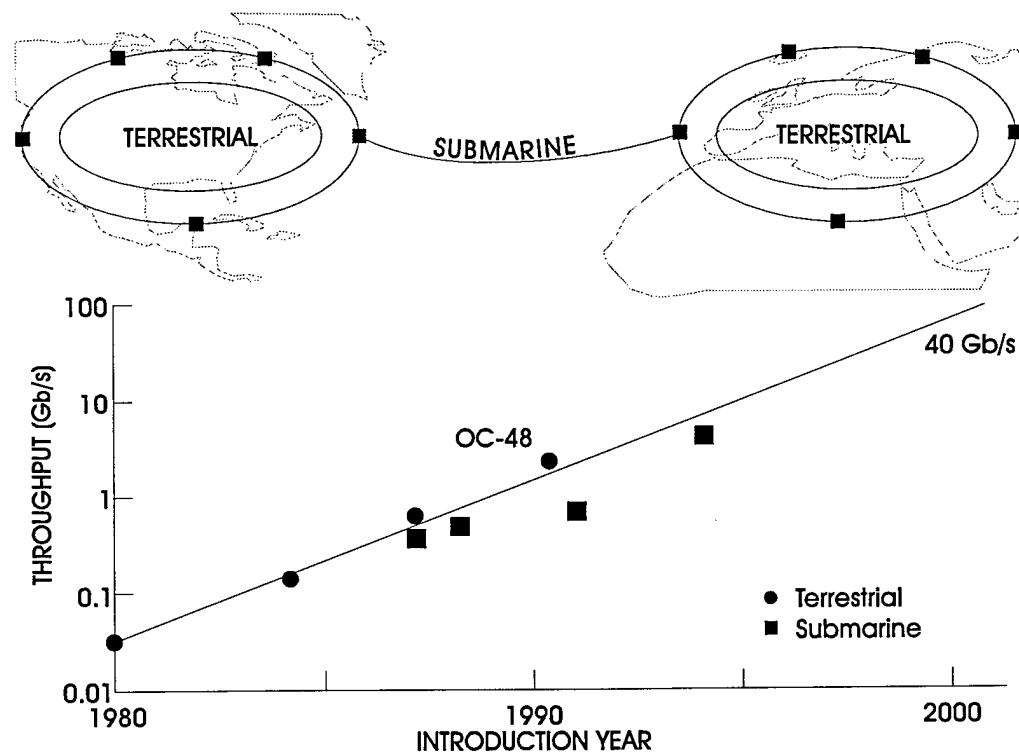


Figure 8. The looming capacity crunch.

³⁰A more detailed discussion of this subject will be included in a report entitled "Competitive Assessment of the U.S. Fiber Optics Industry," performed by the Department of Commerce, International Trade Administration, to be published in early 1994.

A good indication of the strength of U.S. companies' position in the competitive arena can be obtained by assessing the shipments of fiber optic components to users outside the United States. A summary, based on the The Bureau of the Census findings, is provided by ITA³¹. These data are included as Table 7. This summary shows that export of optical sensors, optical emitters, and light-emitting diodes (LEDs) has begun to increase, after a slight decrease in 1991. Based on this analysis, the conclusion is reached that national security is not in danger due to shortages of these components. This study did not analyze the availability of raw materials and consumable materials required to manufacture these devices.

Table 7. U.S. Shipment of Fiber Optic Equipment
(in millions of dollars)

PRODUCT	SIC Code	1990	1991	1992	1993*
Optical Fiber	3231892	\$394.7	\$462.7	\$509.0	\$552.1
Fiber Optic Cable	33579	789.6	733.7	807.1	892.3
Fiber Optic Systems and Equipment	36631	892.2	1,011.6	1,112.7	1,246.2
LEDs	3674912	39.8	39.7	40.4	42.1
Optical Sensors and Emitters	3674924	81.9	74.1	81.5	83.7
Fiber Optic Connectors	3678553	17.6	73.1	80.4	88.6
TOTAL		2,215.8	2,391.8	2,631.1	2,905.0

* Estimated

Source: Current industrial reports, U.S. Bureau of the Census

Ultimately, the strength of U.S. manufacturing is determined by the amount of R & D dollars that can be dedicated to preparing the future technology. One measure of this is to assess the amount that industry is receiving from the U.S. Government. ITA has summarized data³² that is presented here in Table 8. The conclusion can be reached from

³¹Ibid., p. 124.

³²Ibid., p. 125.

the data that the U.S. companies are not faring very well in obtaining R & D help from the U.S. Government.

Table 8. Federal Government Funding of R&D for Optoelectronic/Photonic Technologies (in millions of dollars)

Agency	1991	1992	1993
Commerce	1.2	1.0	0.8
Defense*	86.8	70.9	71.9
Energy	26.5	28.4	28.1
NASA	4.4	4.9	5.2
NSF	23.4	27.0	32.7
TOTAL	142.3	132.2	138.7
Annual % Increase	-----	(10.1)	6.5

Source: Office of Science and Technology, report by the FCCSET committee on Industrial Technology

* Excludes classified research

8. WIRELESS PRODUCTS

The growth of wireless personal communications systems (PCS) has been launched by the tremendous success of cellular radio telephone. The PCS architecture has taken on greater definition in 1992 and 1993. This service is being defined as a "family of services" that will encompass both existing services such as cellular as well as emerging wireless services, many of which are awaiting frequency spectrum allocations before they can be realized. A recent DoC publication³³ has defined the PCS family of services as shown in Table 9.

³³The Department of Commerce, International Trade Administration's *U.S. Industrial Outlook 1993*.

Table 9. PCS Family of Services

Existing Services	Emerging Services
Enhanced Cellular	Advanced Cordless
Enhanced Paging	Wireless Business Service
Enhanced SMR	Telepoint Mobile Satellite Data PCS Wireless LANs Personal Telecommunications

Source: Telocator

The common denominator of all the individualized PCS services is a capability for persons or devices to communicate independent of location. The Federal Communications Commission (FCC) is proceeding toward a goal of completing the rules for licensing PCS. As a highly segmentable industry, PCS may evolve first for office buildings and high density pedestrian applications that cannot be served by cellular on a large scale. Interest is high, and the technology will develop in the future, requiring the development of numerous high-tech products that will be integrated into the NS/EP scenario by NS/EP planners.

The key factors determining the development of the PCS technology, and the proliferation of PCS products, will be:

- ◆ timely Government licensing
- ◆ adequate frequency spectrum
- ◆ access to capital funds
- ◆ the formation of strategic alliances to meet the full range of PCS needs
- ◆ appropriate pricing and distribution strategies
- ◆ phone number and address definition and availability required to facilitate portability.

The success that Government and industry have in implementing these factors will determine the growth of this emerging technology, its acceptance as a part of the NS/EP plan, and ultimately the vulnerability to foreign sourcing. If the development continues, PCS may be extremely vulnerable and susceptible to interruption of many foreign supply sources. The "heart" of most of the PCS products will be some type of semiconductor (e.g., microcontrollers, a digital signal processors (DSPs), flash memories, DRAMs, SRAMs, EPROMs, ASICs, etc). All of the processes for manufacturing these devices are susceptible to shortages of simple raw materials or consumable materials. The vulnerabilities in the supply chain for these items are discussed in Section 6 of this report.

9. SUMMARY OF FINDINGS

Telecommunications technology is fast-changing, experiencing turnover in a matter of months. A company that wishes to participate in this industry must be capable of sustaining the capital investment required to compete by continuously altering market position, and modifying its manufacturing processes to remain efficient as the market for products changes and the process technology evolves. The ability to compete is determined by two factors: the vision to offer the right products to fulfill the customer needs and the resourcefulness to implement the most efficient and cost-effective manufacturing techniques and methods in a timely fashion.

U.S. companies continue to be both inventors of technology and implementors of manufacturing process techniques. In some cases a technology (or product) invented in the United States has been more efficiently or more quickly implemented by a foreign company. Frequently the U.S. inventor has not been properly recognized or compensated for the intellectual rights; however, creation of properly constructed alliances with foreign entities has reduced the outflow of technology without compensation.

U.S companies try to position themselves for maximum profit and a low risk-future, responding to the demands and requirements of their investors and stockholders. These two attitudes determine (sometimes limit) the products and processes that investors are willing to pursue. For example, the pursuit of maximum profit frequently precludes the manufacturing of commodities requiring a high investment and yielding a low return on investment. Many manufacturing organizations consider this to be a "dirty" business (a high overhead business fraught with regulations, such as those of the Environmental Protection Agency). Frequently the only company that can be successful in manufacturing such products or commodities is the company that owns the intellectual property rights (patents, etc.), since the profit margin can be less than the royalties demanded by the patent holder.

U.S. companies have successfully improved their competitive position through the development of industry associations and partnerships in certain industries. Examples of

successful partnerships in the semiconductor industry include: Sematech, Semi/Sematech, and the Semiconductor Industry Association (SIA). Other successes have been demonstrated by the formation of the Land Mobile Radio Industry's organization, (Associated Public Safety and Communications Officials, Inc.), APCO 25, under the sponsorship of the Telecommunications Industry Association (TIA); and the High Frequency Radio Industry's Association, HFIA, under sponsorship of the Armed Forces Communications and Electronics Association (AFCEA). These organizations, sometimes referred to as the "The American Keiretsu," (Burt and Doyle, 1993) if properly structured and managed, can provide a competitive edge for the member companies.

Statements of findings, supported by facts and data provided earlier in this report, are included here in summary:

1. The fast-paced nature (short technology turnover) of the telecommunications technology and process techniques precludes the definition of items (i.e., raw materials, process consumable materials, components, subassemblies, etc.), that are supplied by foreign sources, in sufficient time to respond in a manner that will allow those foreign suppliers to be replaced with U.S. suppliers while the technology is still relevant. Solutions (i.e., development of U.S. sources) to foreign source dependence must be implemented with long-term goals and commitment.
2. A partnership must be formed between the manufacturing company that has the foreign dependence problem and the U.S. company that can develop a local source for the foreign-sources item(s). These partnerships are referred to as "The American Keiretsu" by Burt and Doyle, 1993.
3. The U.S. semiconductor device industry is stronger then in the 1980s, the ability to compete is proven, and the U.S. semiconductor makers are in command of the market for a majority of end-product devices. However, the dependence on process materials (i.e., gases, photolithography items, raw and processed silicon, chemicals, and other consumable materials) from foreign sources is becoming greater (See Appendix A).
4. Telecommunications end product and component manufacturers are concerned about their reliance on foreign supply of certain key components or materials used to build their products (Fallows, 1993)³⁴.

³⁴The referenced article in *The Atlantic Monthly* (pp. 84-85), entitled "Looking at the Sun," cites a report performed by the U.S. Office of Technology Assessment that concluded that several steps in the semiconductor process were dependent solely on Japanese suppliers, and an unsuccessful attempt by the National Security Agency to build a semiconductor manufacturing facility.

5. Most product production processes are reliant on one or more foreign sources for supply of one or more components, subassemblies, raw materials, or consumable material commodity³⁵.

6. The implementation of "lean production" at some factories in the United States has likely increased the exposure to interruption due to foreign supply. The compression of the inventory supply pipeline within the manufacturer's process facility has compounded the vulnerability due to reliance on foreign suppliers. Frequently, the end-product manufacturer does not know the quantity or the location of raw material supply available to his factory because that responsibility has been transferred to the supplier. That supplier may be a foreign entity, or may be dependent on a foreign supplier at a lower tier, for supply of a raw material.

7. U.S. manufacturers are capable of manufacturing or supplying every essential component or material required to produce telecommunications products. The reasons why there are no U.S. manufacturers producing certain products are numerous. These reasons usually stem from an insufficient ROI, that is a result of one of the following factors:

- ◆ inability to compete due to labor costs in the United States
- ◆ inability to compete due to cost of conforming to Environmental Protection Agency (EPA) regulations
- ◆ inability to compete due to cost demanded by proprietary rights (patent) owners
- ◆ inability to compete due to manufacturing costs (higher than foreign competitors) resulting from U.S. tax law structure
- ◆ an unwillingness to sell below cost for an extended period (Fallow, 1993)³⁶.

8. The U.S. manufacturers have been purchased by foreign organizations as a result of insufficient ROI.

9. The formal association of U.S. manufacturers for the purpose of improving the members' competitive position in the marketplace has proven to be beneficial for several industries.

10. Foreign investors have seized investment opportunities in the United States. There is an indication that there has been strategic positioning of these investments in a way that

³⁵Ibid., p. 87.

³⁶The referenced article in *The Atlantic Monthly* discusses the "win at any cost" spirit used by a Japanese company.

could provide control of selected processes. For example, in a typical semiconductor process, foreign suppliers are the only source for certain process equipment and materials.

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11. APPENDICES

1. Appendix A

A briefing to the U.S. Department of Commerce, National Telecommunications and Information Administration, Institute for Telecommunication Sciences, Boulder, CO, by Ms. Peggy Haggerty, Vice President, Public Policy and Administration, Semi/Sematech, Austin, TX on October 8, 1993.

2. Appendix B

A briefing to the U.S. Department of Commerce, National Telecommunications and Information Administration, Institute for Telecommunication Sciences, Boulder, CO, by Mr. Clay Prince, Competitive Analyst, Strategic Integration, Semi/Sematech, Austin, TX on October 8, 1993.

Appendix A

This appendix contains text of a presentation that was delivered at a briefing to the U.S. Department of Commerce, National Telecommunications and Information Administration, the Institute for Telecommunication Sciences, Boulder, CO. The presentation was made by Ms. Peggy Haggerty, Vice President, Public Policy and Administration, Semi/Sematech, Austin, TX. The briefing that was held on October 8, 1993, summarized the results of a study that was commissioned by the National Communications System (NCS), Arlington, VA, that identified areas of vulnerability stemming from foreign source dependence.

PRESENTATION TO THE INSTITUTE FOR TELECOMMUNICATION SCIENCES
U.S. DEPARTMENT OF COMMERCE
BOULDER, COLORADO

OCTOBER 8, 1993

Good morning. I am very pleased to be here today to discuss with you our views of the U.S. materials industry. I will focus my comments on the electronics materials industry while Clay will broach the broader subject of structural and electronic materials.

My presentation is brief but I hope that it will help set the tone for discussion today as well as in the future. I would like to begin with a brief description of SEMI/SEMATECH, the consortium I represent and how it differs from SEMATECH as well as other organizations with which you may be more familiar. I would also like to briefly discuss the structure of the industry, some of the issues that affect a supplier's viability, and highlight an example of materials requirements for a future technology. Many of the foils I will use today show 1990 data, for which I apologize. But, based on the information that Clay and I know, the information is still relevant.

SEMI/SEMATECH is a research and development consortium, established in 1987 by majority owned and controlled U.S. producers of semiconductor manufacturing equipment and processing materials, to assist them in their interactions with SEMATECH and its members. SEMI/SEMATECH is based in Austin, TX at SEMATECH's facilities and has a satellite office in Washington, D.C. We receive no government funding and are dependent on membership dues. Our membership roster currently numbers 144 companies. We are focused on improving the competitive position of our members through improved business practices, strong customer-supplier relationships, and with SEMATECH and its members, through the development and commercialization of leading-edge technology.

SEMI/SEMATECH's members are representative of the U.S. industry by size (2/3 are small businesses earning \$10 million or less in annual sales), by geographic distribution (we have members in 28 states including 2 members in Colorado--Foss Industries in Colorado Springs that manufactures process modules, and Particle Measuring Systems here in Boulder, which is in contamination/defect technology), and by technology area.

SEMI/SEMATECH's mission is "to achieve a continuous improvement in the environment among U.S. users and suppliers of semiconductor manufacturing equipment, processing materials, and software with the objectives of working with the customers collectively for mutual benefit, facilitating continuous improvement of the members to achieve world class competitiveness and by working with SEMATECH on its programs and delivering effective program-related communications to our members."

SEMI (Semiconductor Equipment and Materials International) is a trade association located in Mountain View, California. Its membership is international, it generates most of its revenues from trade shows (SEMICON/West, for example), and it is involved in standards activities.

SIA (Semiconductor Industry Association) is also based in California (Cupertino), it represents U.S. semiconductor companies, and it was established originally to interact with the U.S. Government on international trade matters. The SIA is responsible for the establishment of the Semiconductor Research Corporation (in Research Triangle Park, North Carolina) and SEMATECH. And,

SEMATECH, which is the research and development consortium created by legislation in 1987 as an innovative partnership between the U.S. semiconductor industry and the U.S. Government to focus on semiconductor manufacturing technology. One half of its funding comes from the Advanced Research Projects Agency (at Defense) and the other half comes from its eleven members.

Now, about electronic materials...Why are they important?

In my view, electronic materials are the foundation of the electronics industry. They are the raw input required to manufacture semiconductors, which in turn are the necessary components of computers, cars, planes, and telecommunications products. Compared to the electronics industry, however, the materials industry is very small in size (about \$10billion compared to almost \$1trillion) and its importance is sometimes overlooked.

Structurally, electronic materials suppliers are, generally, subsidiaries or divisions of larger corporations. That is the case with all but one of the top ten U.S. producers (Photronics) and all but one of the top 10 world producers (Komatsu Electronic Metals). Important to note is the share of electronic materials sales to total corporate sales for both, U.S. and worldwide producers.

For the top ten U.S. producers (again with exception of Photronics, which is a dedicated mask producer), sales of electronic materials are a relatively small contributor to total corporate sales, but are, generally, major contributors to the top ten world producers. Another significant point is that there are no U.S. owned suppliers in the top ten world list, the aggregate 1992 sales of the top ten U.S. producers were barely 80% of Shin-Etsu's, the leading world producer and, with the exception of Huls and Hoechst, all of the top world producers are Japanese.

In my view, it is important to understand the relationship between U.S. materials suppliers to their corporate parents to better understand the activities that took place in the 80's and are taking place today.

In the 1980's, national economic conditions and increasing international competitive pressures, forced many companies in the United States to reevaluate their long-term market staying power and core business structures. Managers reviewed contributions of their subsidiaries to total corporate bottom lines and divested themselves of weak performers and non-core businesses. As a result, many U.S. electronic materials suppliers whose own economic performance had weakened, were sold, many of them to foreign purchasers.

Between 1986 and 1988, all but one silicon wafer merchant producer was sold (Ohio-based Cristeco still produces silicon wafers and supplies the 5" niche market). Siltec was sold to Mitsubishi, Huels purchased MEMC, and Osaka Titanium bought Cincinnati Milacron. In 1989, we lost ownership of the sputtering target supply base with the sale of MRC to Sony. And in 1991, Nippon Sanso acquired its second U.S. gas supply company, SEMIGAS, and became one of the largest world gas suppliers. It had purchased Matheson Gas Products in 1986.

Further downsizing is occurring in the 1990's and I believe that the U.S. electronic materials industry will continue to be affected as a result.

Many different issues affect a suppliers' viability such as a competitive and increasing customer base, research and development expenditures, environmental requirements and costs.

Materials suppliers have traditionally located close to their customer base. During the 1980's, the U.S. semiconductor industry suffered considerable market share losses to the Japanese which produced a decline of the domestic customer base for the electronic materials industry. Conversely, the Japanese semiconductor industry grew exponentially strengthening the Japanese materials industry.

A smaller domestic customer base meant a reduction in profitability, although R&D expenditure levels had to be maintained at historical levels to ensure future viability. SEMI/SEMATECH members in the materials segment indicate that their R&D expenditures often exceed 22% of sales every three years. In addition to continuous R&D in new materials, producers must also invest considerable capital in upgrading and retrofitting equipment and facilities. And, as semiconductor geometries are reduced and new technologies evolve requiring higher performing materials with smaller concentrations of contaminants, electronic materials producers find themselves with more pressures being added to their overall performance without a comparable growth in the market base.

In addition, environmental imperatives and overall new semiconductor facilities' costs are driving customers to seek alternatives to the types, quantities and disposal of materials, particularly chemicals. Present-day state of the art semiconductor facilities and future ones, are focusing on recycling materials, which reduces the volume of materials sold and, are requiring that suppliers own or manage the entire electronics materials operations in the manufacturing facilities to reduce their own costs and liabilities. These factors, plus the size of the existing competition, continue to weaken the U.S. electronic materials industry.

Does a non-competitive or non-existing domestic materials infrastructure harm the U.S. high technology industries' progress?

That is a subject that is now beginning to be discussed. SEMATECH and SEMI/SEMATECH both believe that it is important to have a domestic materials infrastructure since current and future technologies are dependent on their products. For example, a large variety of materials are needed to manufacture liquid crystal displays. With few exceptions, there are no viable U.S. producers for most of them.

Maybe having a U.S.-owned and controlled electronic materials infrastructure doesn't matter, as long as we have adequate sources of supplies and ready access to them. But before we continue to let the U.S. electronic materials industry deteriorate through inaction, we should think about the consequences, discuss them, and decide in which direction to go.

Thank you.

A Presentation to the
U.S. Department of Commerce

Peggy Haggerty
Vice President
SEMI/SEMATECH

OUTLINE

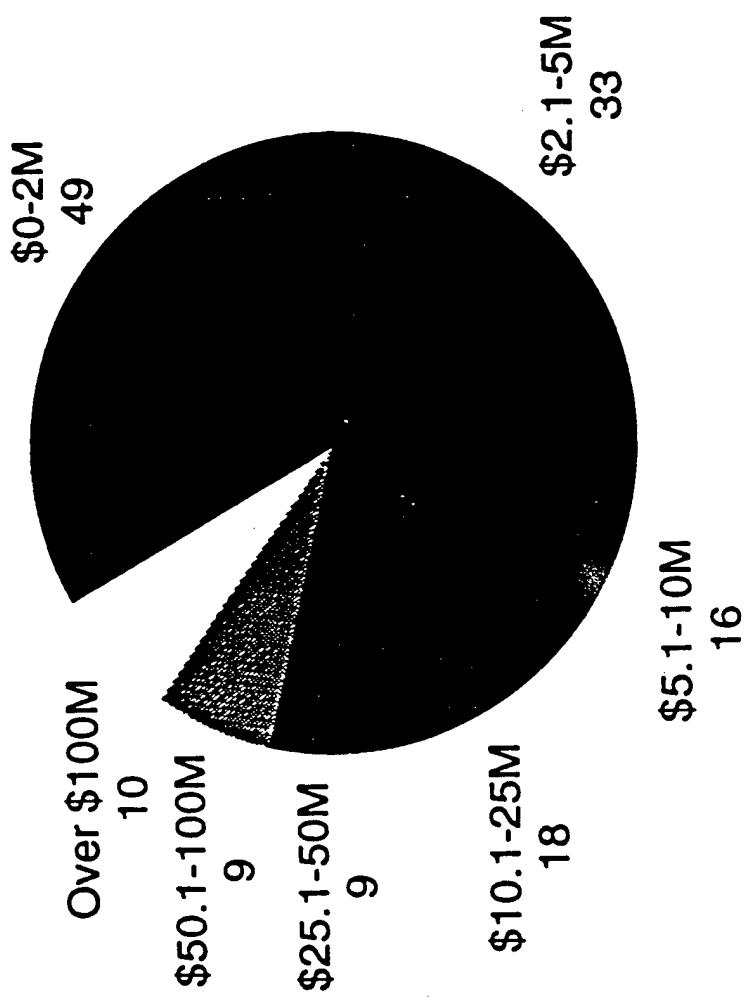
- I. Description of SEMI/SEMATECH, Mission and Member Demographics
- II. Electronic Materials Infrastructure -- Description
- III. Forces affecting Viability of Suppliers
- IV. Example of Future Technology Requirements
- V. Conclusion

SEMI/SEMATECH

- o established in 1987 to facilitate the interaction of U.S. suppliers with SEMATECH and its members
- o represents 144 majority U.S.-owned and controlled suppliers to the semiconductor industry
- o based in Austin, Texas at SEMATECH's headquarters with a satellite office in Washington, D.C.
- o focused on improving the U.S. competitive position through leading-edge technology, improved business practices, and strong customer-supplier relationships

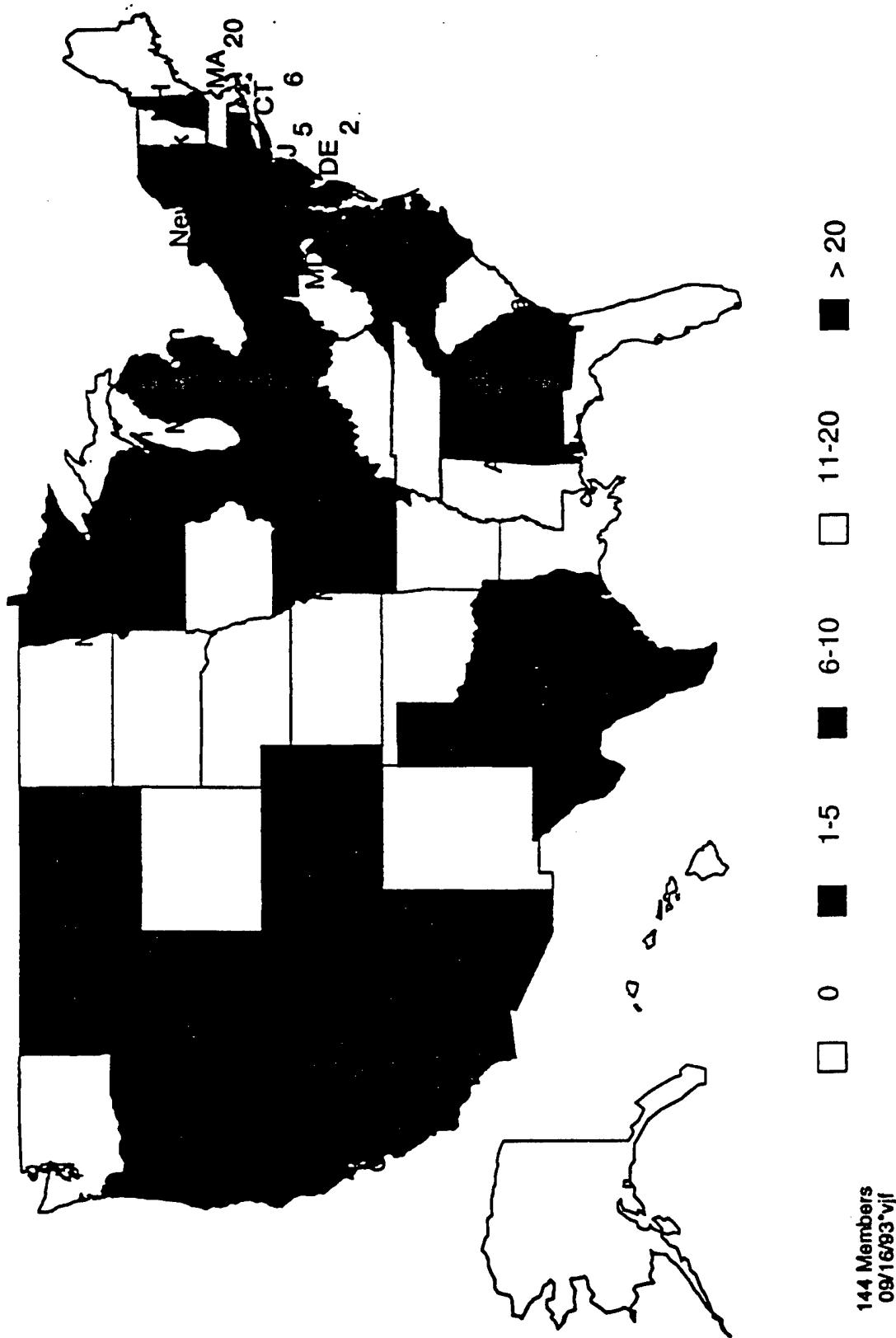
SEMI/SEMATECH MEMBERS

Annual Sales



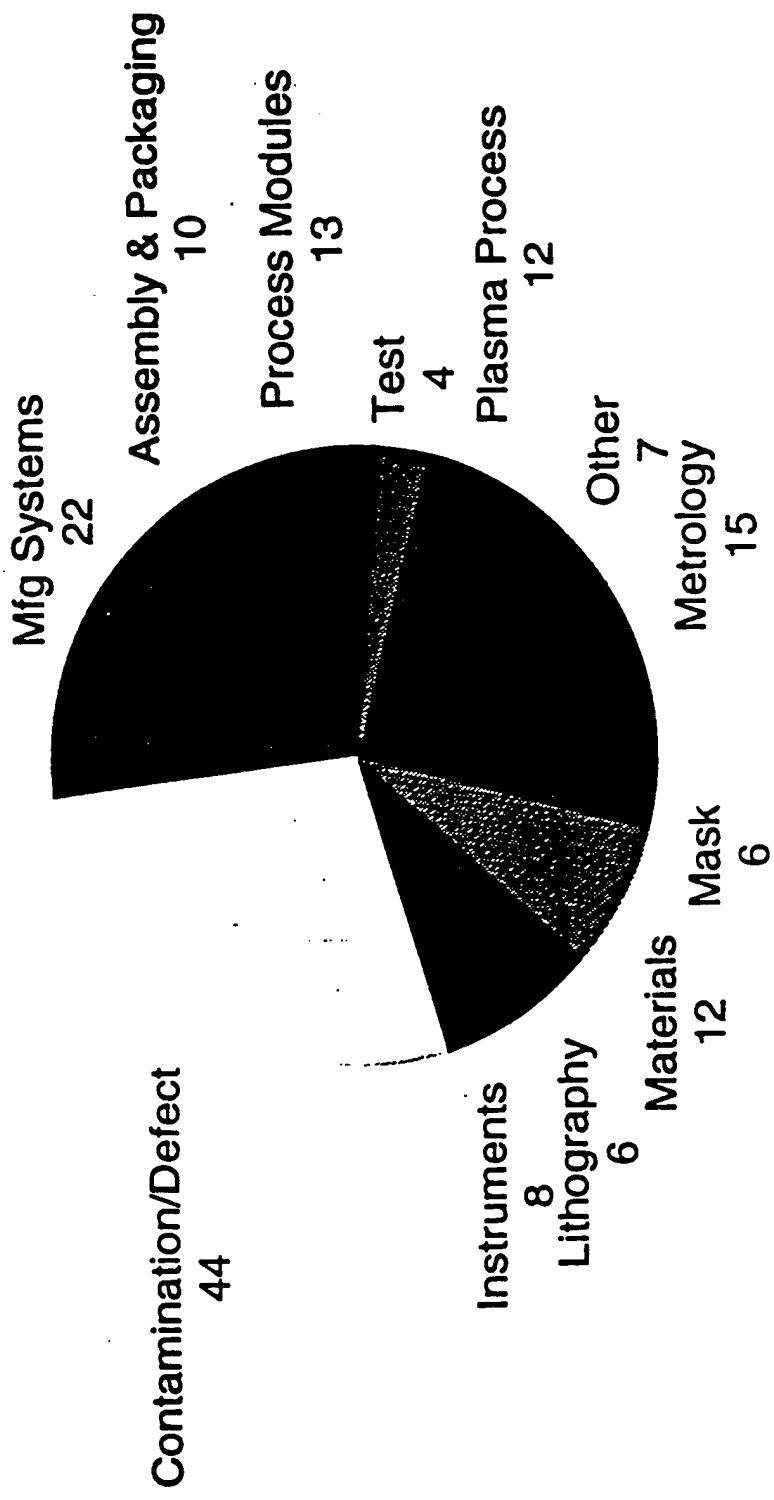
144 Members
10/04/93 v1

SEMI/SEMATECH Members' Home Office Locations



SEMI/SEMATECH MEMBERS

Product Categories



144 Members
10/04/93-v1

SEMI/SEMATECH's Mission:

"To achieve continuous improvement in the environment among U.S. users and suppliers of semiconductor manufacturing equipment, processing materials, and software with the following objectives:

1. Work with our customers collectively for mutual benefit
2. Facilitate continuous improvement of our members to achieve world-class competitiveness
3. Work with SEMATECH on its programs and deliver effective program-related communications to our members."

SEMI (Semiconductor Equipment & Materials International)

- o A Trade Association
- o Sponsors International SEMICON Trade Shows
- o Involved in Standards Activities
- o Global Membership
- o Based in Mountainview, CA with Satellite Offices in Washington, D.C., Europe, and Asia
- o President: William Reed

SIA
(Semiconductor Industry Association)

- Represents U.S. Semiconductor Manufacturers
- Influences U.S. Government Policies to Help Ensure U.S. Competitiveness in Semiconductors
- Primary Focus on International Trade, Specifically Unfair Trade Practices and Increased Access for U.S. Products in World Markets
- Based in Cupertino, CA
- President: Andy Procassini

**INCORPORATED ON AUGUST 7, 1987
SEMATECH IS A PARTNERSHIP AMONG**

AMD

AT&T

DIGITAL EQUIPMENT

MOTOROLA

NATIONAL SEMICONDUCTOR

NCR

HEWLETT-PACKARD

ROCKWELL

INTEL

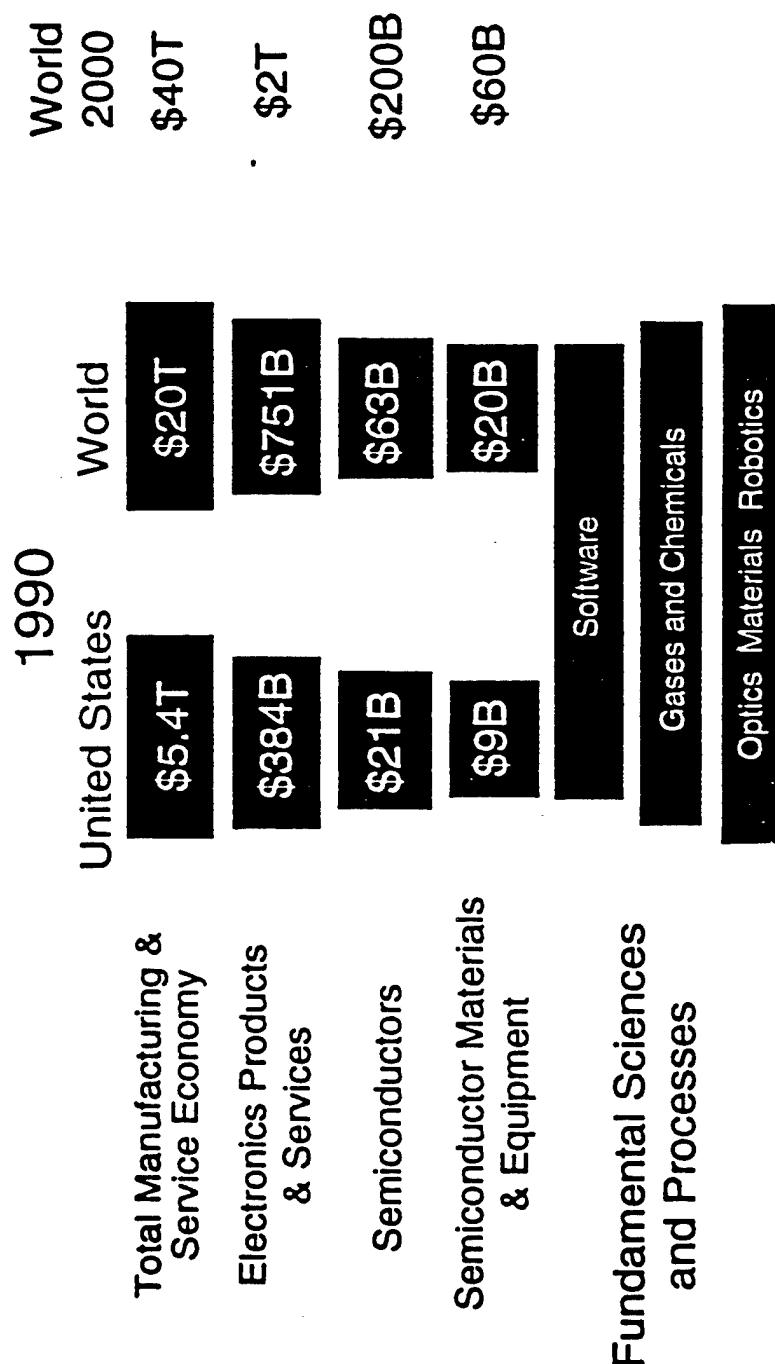
TEXAS INSTRUMENTS

IBM

**SEMI/SEMATECH
THE AMERICAN GOVERNMENT,
AND THE AMERICAN PEOPLE**

SEMI/SEMATECH

Semiconductors & the Infrastructure: The Multiplier Effect



Source: NACS, DataQuest, & AEA
02/08/93 vj

SEMI/SEMATECH

Top Ten U.S.-Owned Semiconductor Material Suppliers

	1992 VW Semi Mats Sales (\$M)	% Total Corp. Sales	Products
Air Products	160	5.3	Gas, Chemicals
DuPont	140	0.4	Photomasks, Gas, Chemicals
Rohm & Haas	120	4.3	Photoresist, Mold Compound
National Semi (DCI)	120	7.0	Leadframes
Dow-Corning	100	5.6	Polysilicon, Silicone
Ashland Oil	75	0.8	Chemicals
Praxair	70	2.7	Gas
Olin	65	2.8	Photoresist, Chemicals
Photronics	42	100.0	Photomasks
Dexter	40	4.0	Mold Compound, Epoxies
TOTAL	932		

Source: Rose Associates

**Top Ten Worldwide
Semiconductor Material Suppliers**

	1992 WW Semi Mats Sales (\$M)	% Total Corp. Sales	Products
Shin-Etsu Chemical	1188	33	Wafers, Resins
Kyrocera	890	26	Ceramic Packages
Huls (MEMC)	530	9	Wafers
Hoechst (Wacker)	510	2	Wafers, Chemicals
Shinko Electric	505	80	Leadframes, Ceramic
Dai Nippon Printing	450	5	Leadframes, Masks
Osaka Titanium	446	86	Wafers
Mitsubishi Mtl	433	5	Wafers, Wire, Targets
NGK Spark Plug	390	42	Ceramic Packages
Komatsu Electronic Metals	385	100	Wafers, Gas
TOTAL	5727		

Source: Rose Associates

Semiconductor Material Suppliers

TOP 10 WORLD

	% Total Corp. Sales	
Shin-Etsu Chemical	33	
Kyocera	26	
Huls (MEMC)	9	
Hoechst	2	
Shinko Electric	80	
Dai Nippon Printing	5	
Osaka Titanium	86	
Mitsubishi Mati	5	
NGK Spark Plug	42	
Komatsu Electronic Metals	100	
		\$5.727B

TOP 10 U.S.

	% Total Corp. Sales	
Air Products	5.3	
DuPont	0.4	
Rohm & Haas	4.3	
National Semi (DCI)	7.0	
Dow-Corning (Hemlock)	5.5	
Ashland Oil	0.8	
Praxair	2.7	
Olin	2.8	
Photronics	100.0	
Dexter	4.0	
		\$932M

Source: Rose Associates

Corporate Strategies: 1980 & 1990

Semiconductor
Materials
Out

U.S.
Corporate
Focus

Core
Business

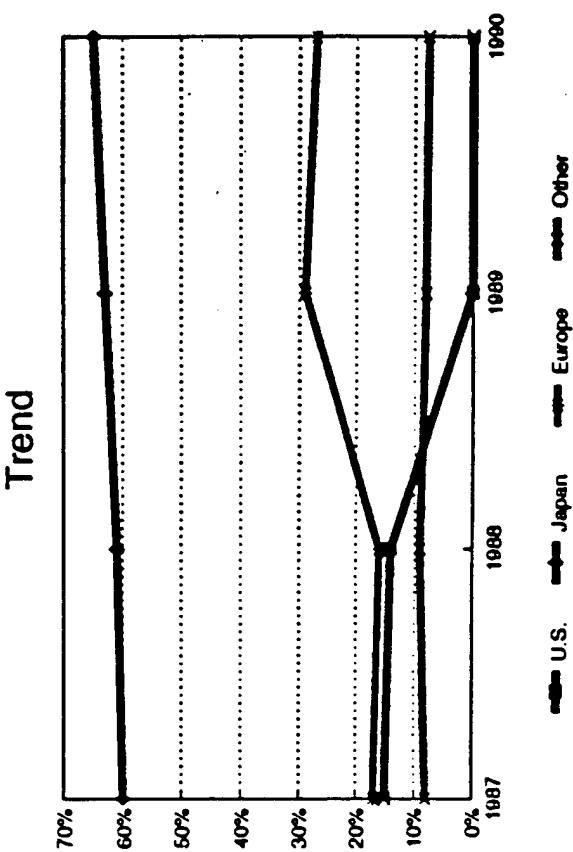
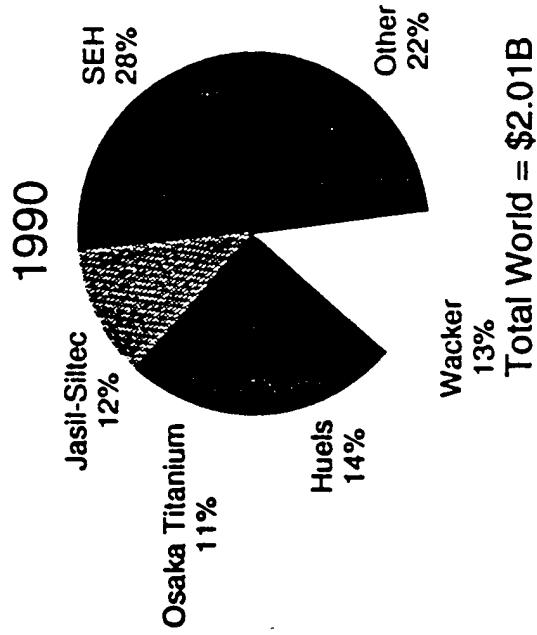
1980

Downsizing
for
Profitability

1990

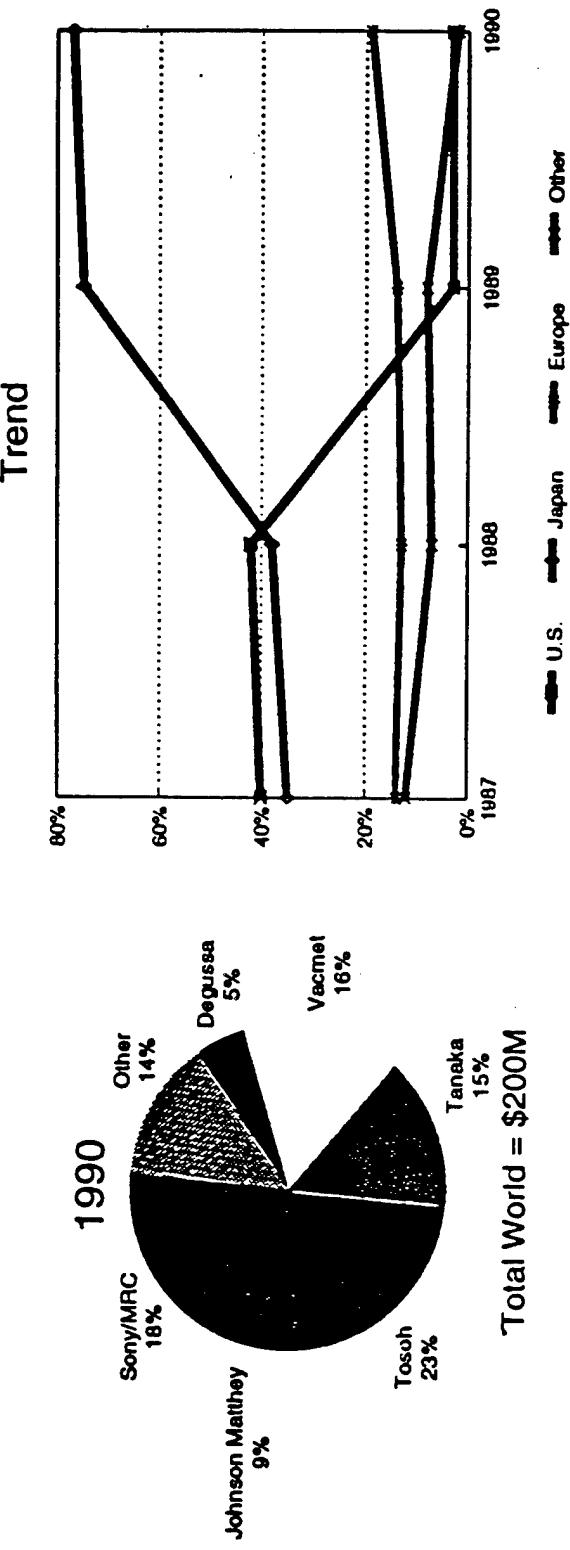
Source: Rose Associates
10/06/93*vf

Silicon Wafer Suppliers



Source: Rose Associates
060881-14

Sputtering Target Suppliers



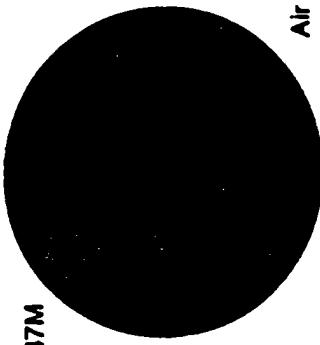
Note: Alcoa is the largest remaining U.S. supplier with \$6M in sales.

Source: Rose Associates
0809914

SEMI/SEMATECH

Gas Suppliers

1990

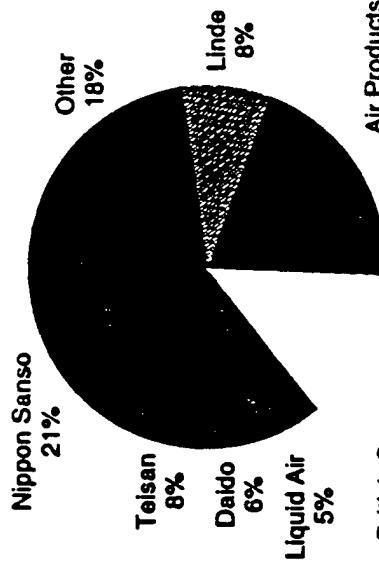


Linde \$47M

Air Products \$116M

Total North America = \$163M

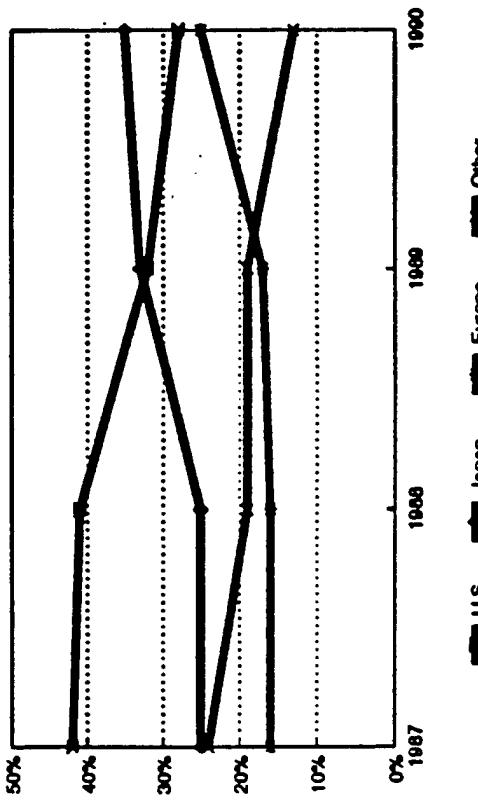
1990



Total World = \$580M

Source: Rose Associates
0800014

Trend



SEMI/SEMATECH

FACTORS DRIVING CHANGE IN THE MICROELECTRONICS MATERIALS

- <1> NO GROWTH IN REAL VOLUME MICROELECTRONICS MATERIALS CONSUMED
- <2> NEW ELECTRONIC MATERIALS MARKETS OFTEN EVOLVE FROM DEVELOPMENTS SUPPORTED BY NON-ELECTRONICS MARKETS
- <3> EXTREMELY LONG DEVELOPMENT CYCLE TIMES
- <4> MICRO-CONTAMINATION CONTROLS REQUIRING MORE SOPHISTICATED SUPPORT EQUIPMENT
- <5> PROLIFERATION OF MATERIAL TYPES WITHIN PARTICULAR MATERIAL MARKET SEGMENT
- <6> TREND TO RECYCLE CHEMICALS -- REDUCE VOLUME & INCREASES UNIT COSTS

WW LCD Material Forecast
(Millions of Dollars)

	ACTUAL	FORECAST	
	1992	1993	1995
Glass Substrates	166	230	360
Polarizer Film	262	330	450
Color Filters	74	220	530
Liquid Crystal	96	180	340
Photoresists & Ancillaries	32	56	125
Alignment Film	30	40	80
Phase Shift Film	36	56	82
Photomasks	40	52	96
Sputtering Targets	14	28	66
Other	25	40	80
TOTAL	775	1232	2209

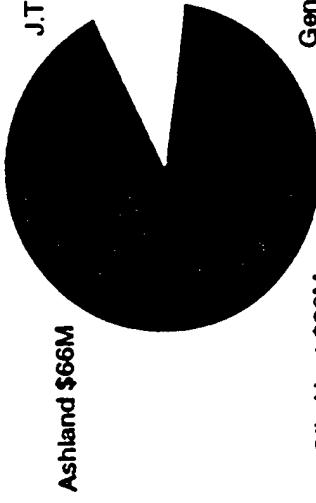
Source: Rose Associates

Conclusion

- o Electronic materials are the foundation of high technology products
- o U.S. position is fragile at best
- o Rebuilding the U.S. materials infrastructure is daunting even for the most optimistic
- o Adequate supply necessary across national borders
- o U.S. government and industry must work together to reclaim viability
- o SEMATECH and SEMI/SEMATECH working together to help the infrastructure survive

Wet Chemicals Suppliers

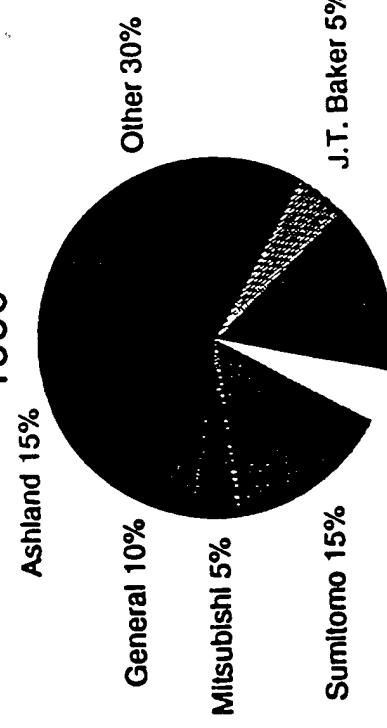
1990



Olin Hunt \$20M

Total North America = \$162M

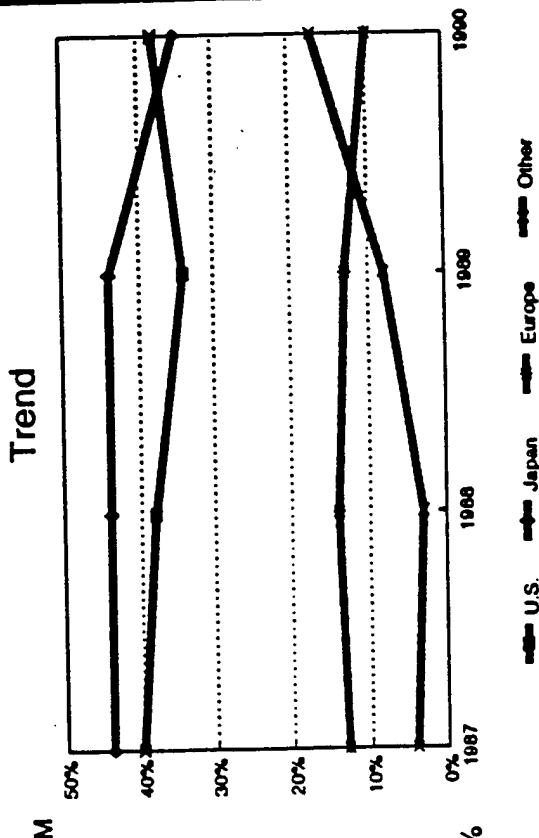
1990



Olin Hunt 5%

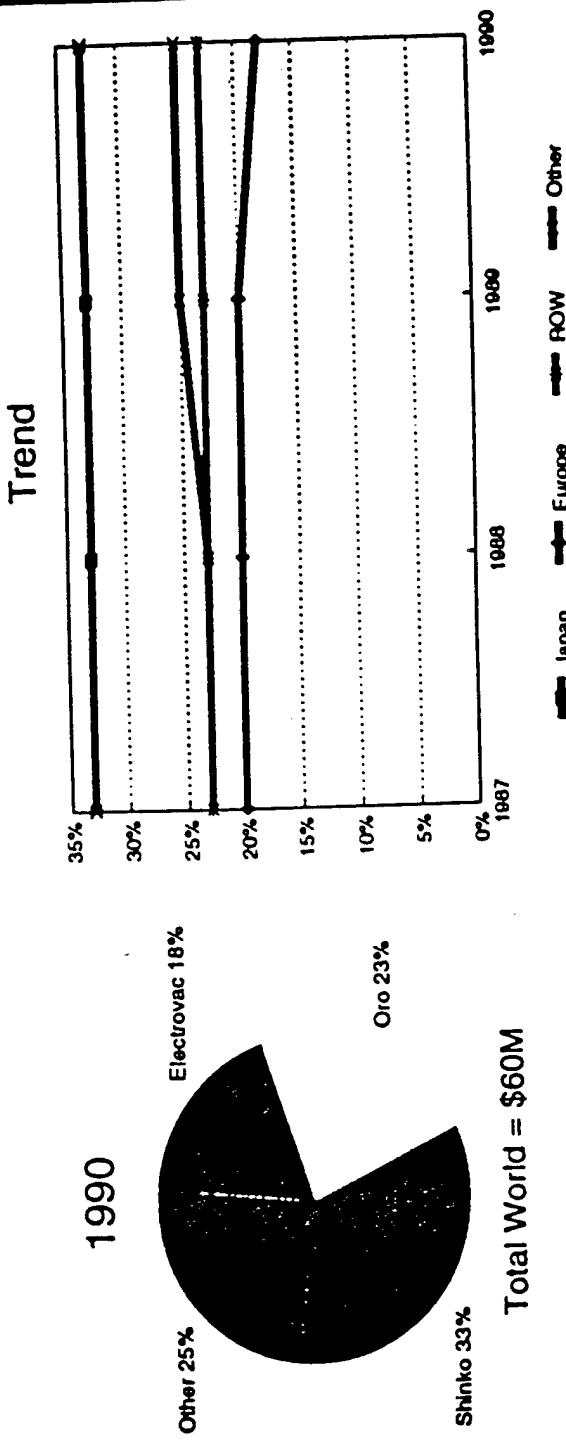
Total World = \$427M

Sources: Rose Associates
08/08/91



SEMI/SEMATECH

Header Suppliers



Note: There are only a few, small U.S. suppliers.
They are all included in the "Other" category.

Source: Rose Associates
08/09/91

Photoresist Suppliers

1990



1990

Tokyo Ohka 37%

JSR 7%

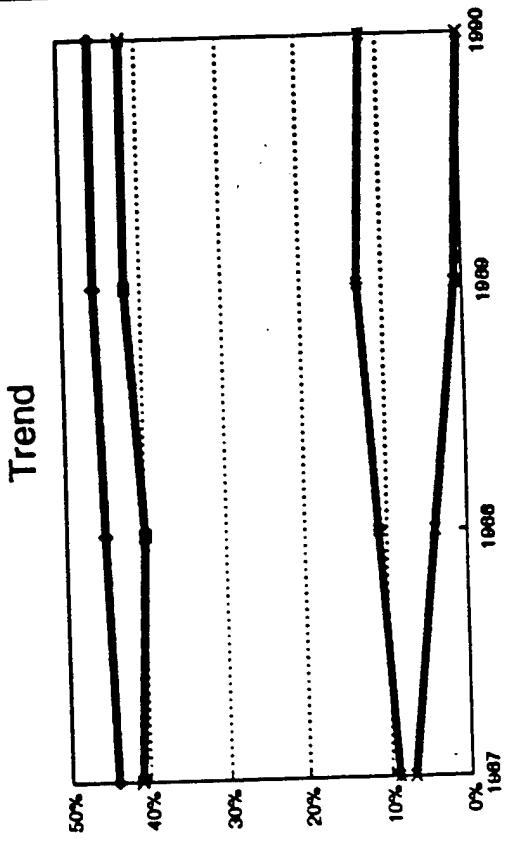
Hoechst 11%

Other 6%

Olin Hunt 13%

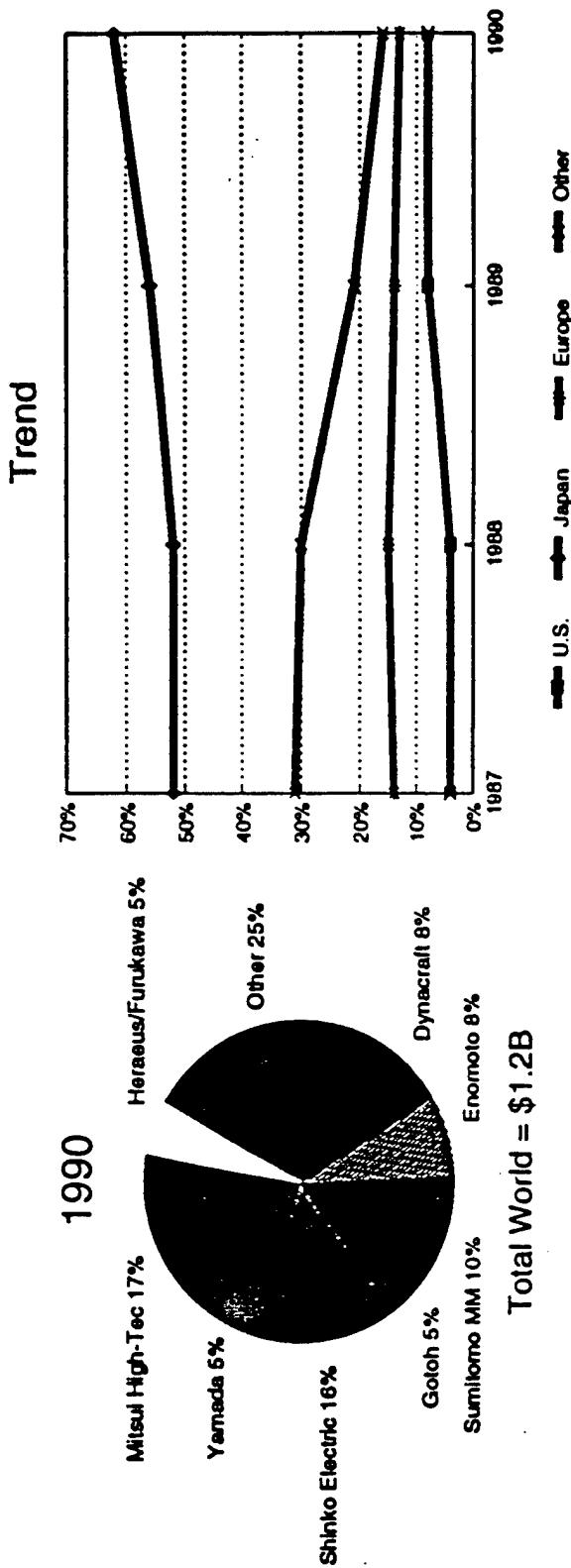
KTI 7%

Total World = \$242M



Sources: Rose Associates
08/09/91 #

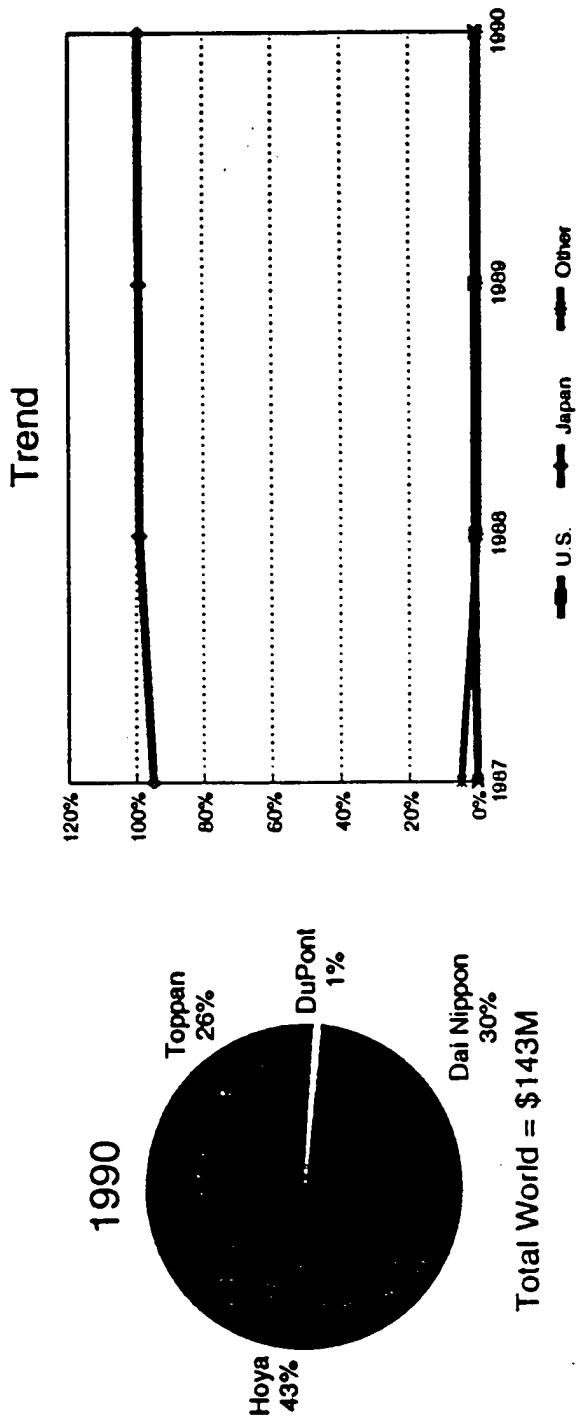
Leadframe Suppliers



Note: Dynacraft is the largest remaining U.S. supplier with \$101M in sales.

Source: Rose Associates
08099174

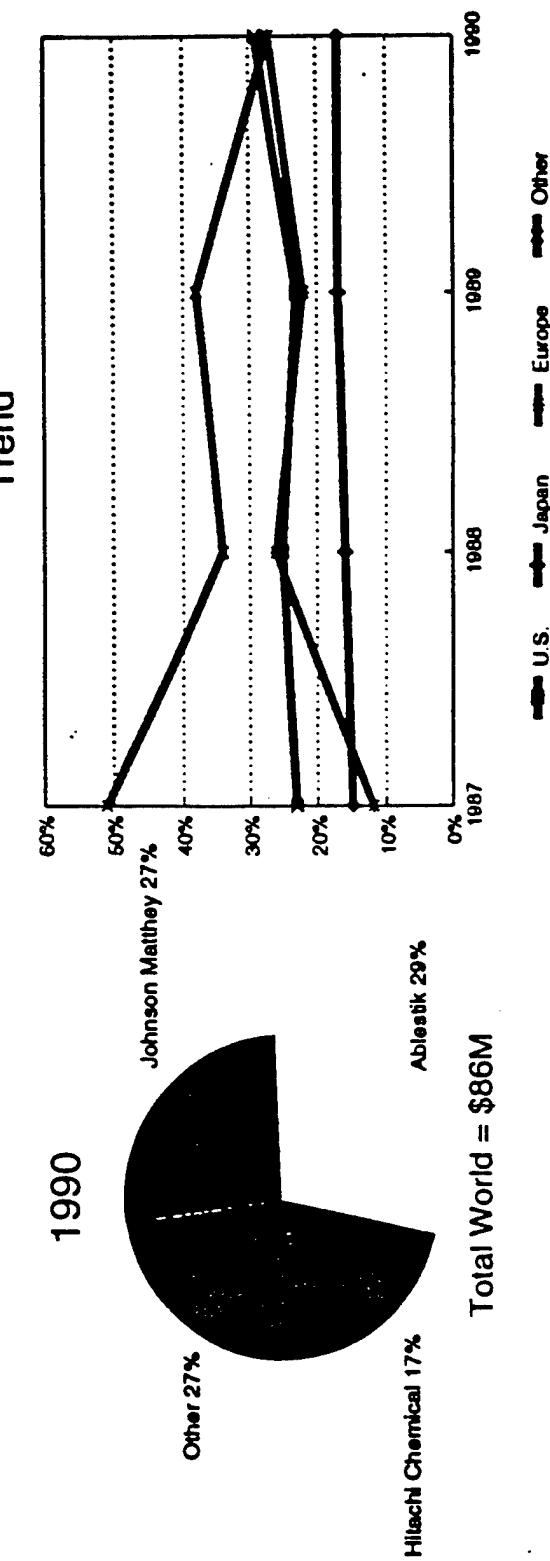
Photoblank Suppliers



Note: Dupont is the largest remaining U.S. supplier with \$1M in sales.

Source: Rose Associates
08/09/91-14

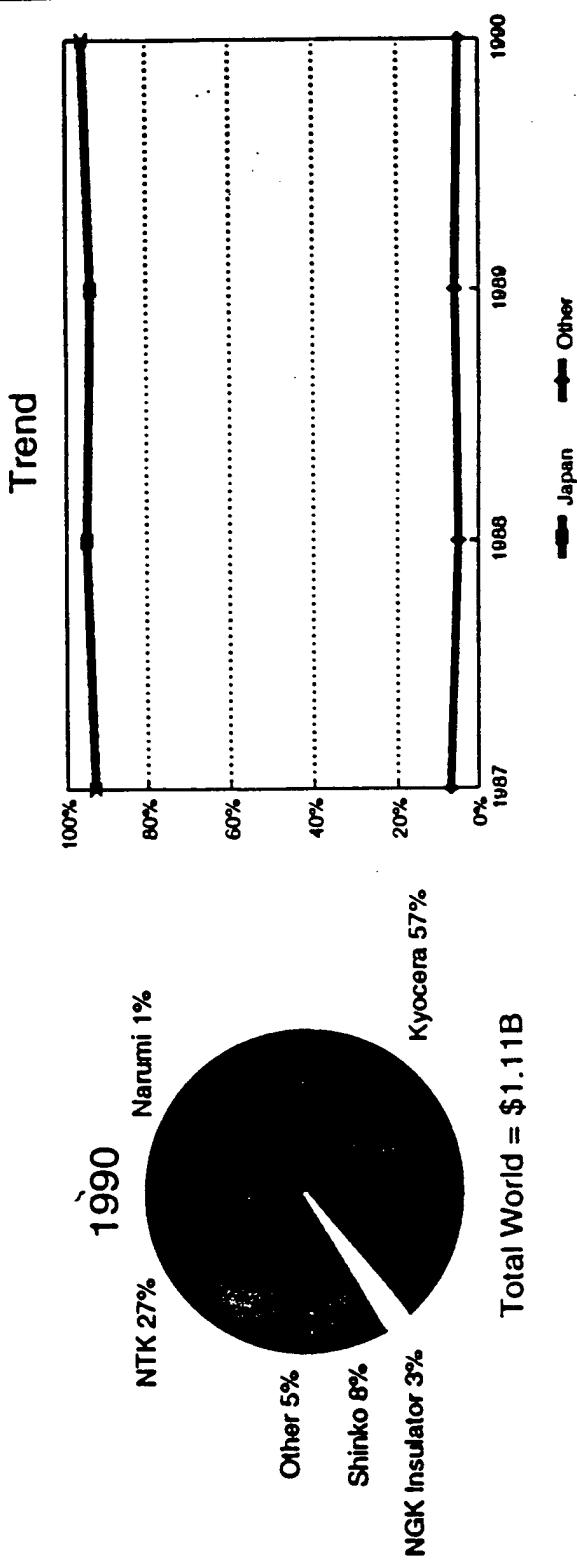
Die Attach Material Suppliers



Note: Ablestik is the largest remaining U.S. supplier with \$25M in sales.

Source: Rose Associates
080201-4

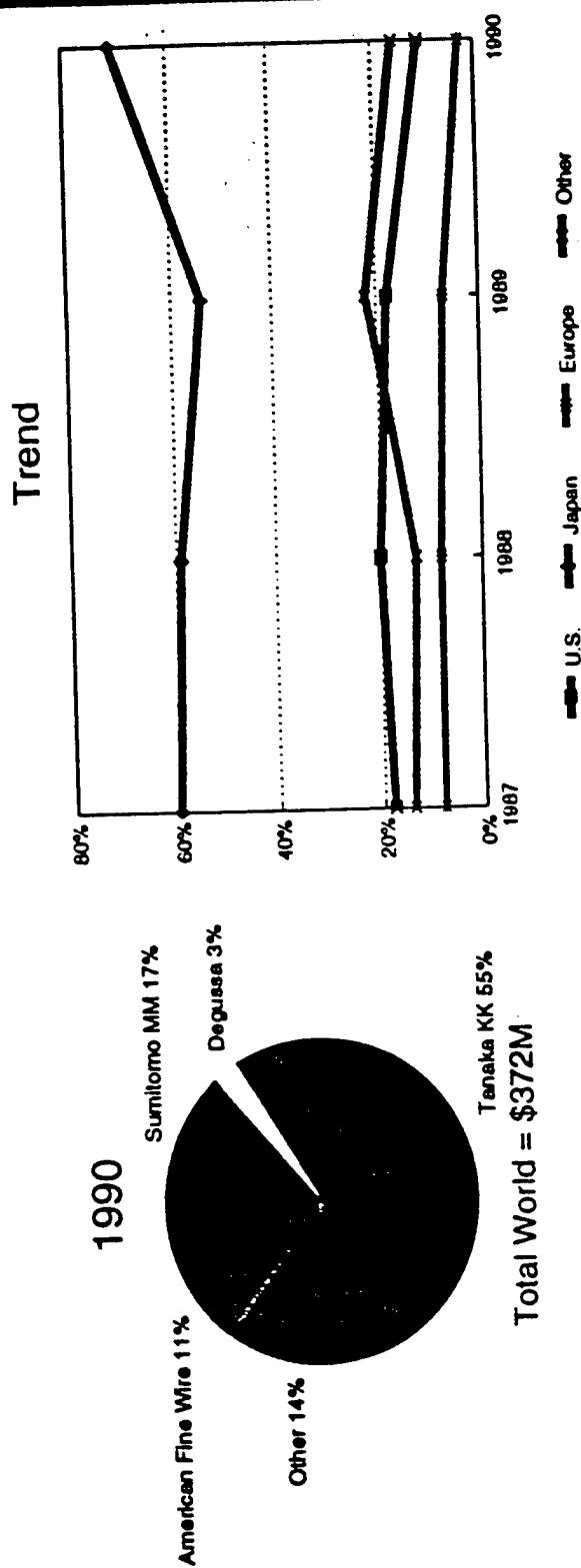
Multilayer Ceramic Package Suppliers



Note: There are only a few, small U.S. suppliers. They are all included in the "Other" category. Alcoa and Coors are the largest remaining U.S. suppliers.

Source: Rose Associates

Bonding Wire Suppliers



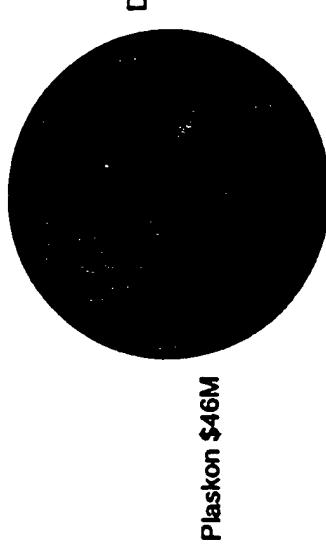
Note: American Fine Wire is the largest remaining U.S. supplier with \$40M in sales.

Source: Rose Associates
08000001-44

SEMI/SEMATECH

Molding Compound Suppliers

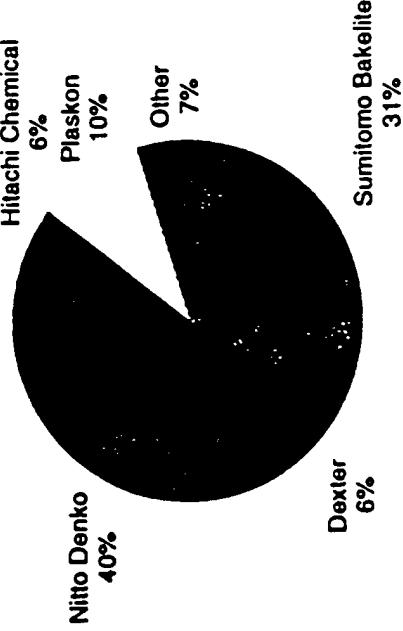
1990



Dexter \$28M

Total North America = \$459M

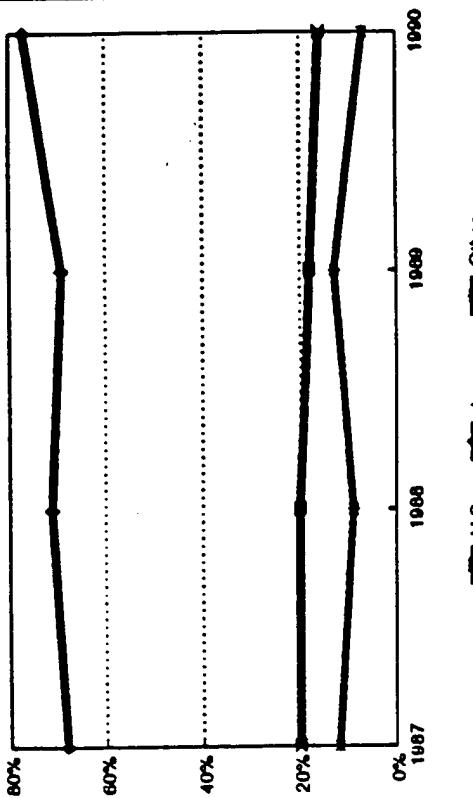
1990



Total World = \$459M

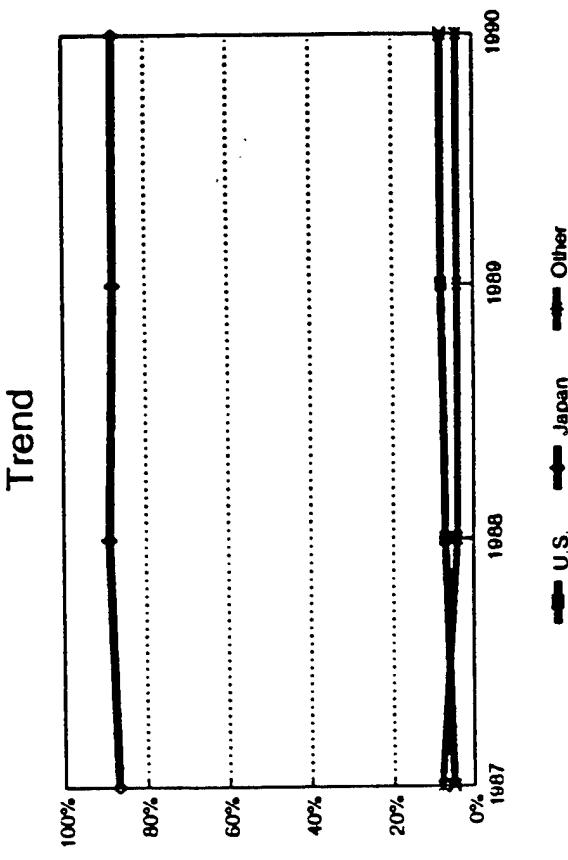
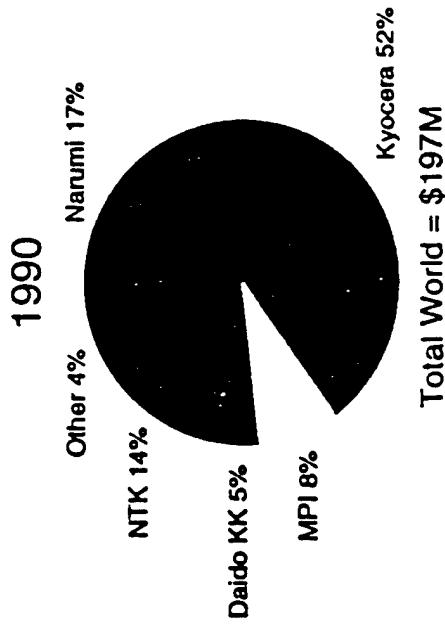
Source: Rose Associates
0808914#

Trend



SEMI/SEMATECH

Cerdip Suppliers



Note: MPI is the largest remaining U.S.-owned supplier with \$16M in sales.

Source: Rose Associates
060991-47

SEMI/SEMATECH

Appendix B

**"MATERIALS: WINNING (or losing)
IN AN INTERNATIONAL MARKET PLACE"**

by Mr. Clay Prince, Sematech, Austin, TX

This appendix contains an abstract of a talk given on October 8, 1993 as part of a briefing hosted at the Department of Commerce, National Telecommunications and Information Administration, the Institute for Telecommunication Sciences, Boulder, CO. This briefing was a "deliverable" for a study funded by the National Communications System (NCS), Arlington, VA. The study began an effort to identify vulnerabilities that may exist for the National Security and Emergency Preparedness (NS/EP) program, due to foreign source dependence. During the study, it was determined that the semiconductor industry and other industries are dependent on basic raw materials and consumable materials, used in the manufacturing process. This talk discussed some of the issues that are the "root" cause of U.S. companies' inability to compete in the production of certain materials.

NATIONAL TELECOMMUNICATIONS & INFORMATION ADMINISTRATION

"MATERIALS: WINNING (or losing) IN AN INTERNATIONAL "MARKET PLACE"

Clay C. Prince
10/8/93

Abstract

A nation's wealth derives in large measure from its industry. Industrialized economies rely increasingly upon digital electronics in industry to speed production, increase yields, facilitate predictable process modeling, and improve profitability. Digital electronics, consequently, plays a key role in industrial productivity. The fundamental ingredients of digital electronics are electronic materials. There is, therefore, a traceable link between electronic materials and industrial productivity, and between electronic materials and national wealth. The electronic materials industry is the infrastructure upon which wealth creating industrial enterprise rests.

The electronic materials industry is generally characterized by low profit margins. Over the past several years U.S. firms have divested themselves of low profit electronic materials divisions, selling to foreign companies willing to commit to the heavy capital investment required for competitiveness in the materials sector. Japan has been the leader among foreign nations in the acquisition of materials infrastructure technologies and companies. Japan currently controls more than half of the entire electronics materials industry and more than two thirds of the semiconductor materials industry (semiconductor materials are used in wafer fabrication and device packaging, and constitute an important subset of electronic materials). More than simply the independent actions of Japanese firms, acquisition of the materials infrastructure appears to be a key element in Japan's strategy for wealth creation. Control of the electronic materials infrastructure eventually leads to control of industrial production.

Japan's example of electronic materials infrastructure acquisition and development is being followed by other nations: Korea, China, Taiwan, the EC, and the former Soviet States are building materials infrastructures. In 1992 the ten largest U.S. semiconductor materials companies comprised only 8% of the world wide market place, while Japan's top eight alone constituted more than 41%. Both U.S. and foreign analysts point out that competitiveness and international independence — sovereignty — depend upon control of the technology "foodchain" which feeds the information technology industry, which, in turn, supports virtually all industrial enterprise.

In 1993 the SEMATECH Board of Directors identified semiconductor materials as a strategically vital element of U.S. semiconductor industry competitiveness and established the SEMATECH Materials Thrust. The SEMATECH Materials Thrust has begun mapping the materials used in present generation devices, and identifying potential bottlenecks to production and delivery of these materials. Identified materials exposures will be prioritized and methods to minimize exposure will be evaluated. This effort will be continued for successive technology generations, with the output supporting the National Technology Roadmap and going into a database for use by SEMATECH members. This effort will involve enlisting the aid of both SEMATECH member companies and national laboratories engaged in electronic materials research, in order to maximize information return, minimize redundancy in the discovery process, and forge public-private sector relationships that will strengthen the U.S. semiconductor industry in the future. The challenges ahead for the SEMATECH Materials Thrust are considerable, yet meeting them represents an important step toward assuring the U.S. of access to the wealth creating materials and technologies of decades to come.

NATIONAL TELECOMMUNICATIONS &
INFORMATION ADMINISTRATION

INSTITUTE FOR TELECOMMUNICATIONS SCIENCE

"MATERIALS: WINNING (or losing)
IN AN INTERNATIONAL MARKET
PLACE"

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October 8, 1993

Importance of the materials industry

- The materials industry forms the foundation of the semiconductor industry
- The semiconductor industry is the lowest common denominator across the industrial base
- Every other industry depends on it
- U.S. autonomy is ultimately bound to the fortunes of the U.S. semiconductor industry

The materials industry is the root of national wealth creation for decades to come.

Global materials trends

- Overcapacity in some market sectors (i.e., Photoresist)
- All industrialized / industrializing nations building electronic materials infrastructures, except the U.S.
- All industrial nations recognize the role of materials in creating wealth
- Margins still very low
- Japan holds a dominating position
- Japanese strategy for wealth creation begins with materials

Materials infrastructure

"In this case (small U.S. semiconductor industry firms versus large Japanese firms) David did not beat Goliath. The moral of the story: A solid industrial structure beats individual brilliance."

Lester Thurow, Author, Head to Head

"The home base is where strategy is set, core product and process development takes place, and the essential and proprietary skills reside."

Michael Porter, Author, The Competitive Advantage of Nations

"The nation or continent that aspires to be internationally independent and competitive in the information technology sector must command the entire "food chain" from semiconductors to end products."

Anton Peisl, Member of the Board of Directors at Siemens AG, of West Germany

"No Japanese and no European experts in high technology advocate indifference to becoming technologically dependent on foreign supply sources."

Former U.S. Deputy Trade Representative Ambassador Michael B. Smith

Critical role of technology

- Technological superiority is a prerequisite for commercial success
- Commercial success is a prerequisite for economic success
- Economic success is a prerequisite for maintaining wealth
- Wealth is a prerequisite for lasting security

Logistical autonomy is a prerequisite for sustaining all

SEMATECH plans

- Broadened mission includes materials
- Materials Program to be initiated this year
- Developing methodology for identifying scope of dependency
- Food chain bottleneck study underway
- Evaluating database options for access by member companies

Summary

- All industrial enterprise depends upon materials
- Industrial (economic) “grand strategy” calls for food-chain dominance
- Cooperation among companies in vertical industries is important; cooperation between sectors is also important
- Japan’s industrial / economic engine -- the keiretsu system -- is structured to pursue both electronic and structural materials; Japan continues to gain
- U.S. industry is dependent upon foreign sources of vital materials
- The playing field is level, must know the rules

Summary, cont'd

- The materials industry is being cultivated in industrializing nations
- The materials industry is the tool by which wealth will be created and maintained in decades to come
- The U.S. materials industry has been in decline for years; this trend must be reversed despite increasing margin pressure
- SEMATECH has broadened its mission to include electronic materials